Scan Team Report

NCHRP Project 20-68A, Scan 08-02

Best Practices In Maximizing Traffic Flow On Existing Highway Facilities

Supported by the

National Cooperative Highway Research Program

August 2011

The information contained in this report was prepared as part of NCHRP Project 20-68A U.S. Domestic Scan, National Cooperative Highway Research Program.

SPECIAL NOTE: This report IS **NOT** an official publication of the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, or The National Academies.

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The purpose of each scan and of Project 20-68A as a whole is to accelerate beneficial innovation by facilitating information sharing and technology exchange among the states and other transportation agencies, and identifying actionable items of common interest. Experience has shown that personal contact with new ideas and their application is a particularly valuable means for such sharing and exchange. A scan entails peer-to-peer discussions between practitioners who have implemented new practices and others who are able to disseminate knowledge of these new practices and their possible benefits to a broad audience of other users. Each scan addresses a single technical topic selected by AASHTO and the NCHRP 20-68A Project Panel. Further information on the NCHRP 20-68A U.S. Domestic Scan program is available at
http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1570.

This report was prepared by the scan team for Scan 08-02, *Best Practices in Maximizing Traffic Flow on Existing Highway Facilities,* whose members are listed below. Scan planning and logistics are managed by Arora and Associates, P.C.; Harry Capers is the Principal Investigator. NCHRP Project 20-68A is guided by a technical project panel and managed by Andrew C. Lemer, PhD, NCHRP Senior Program Officer.

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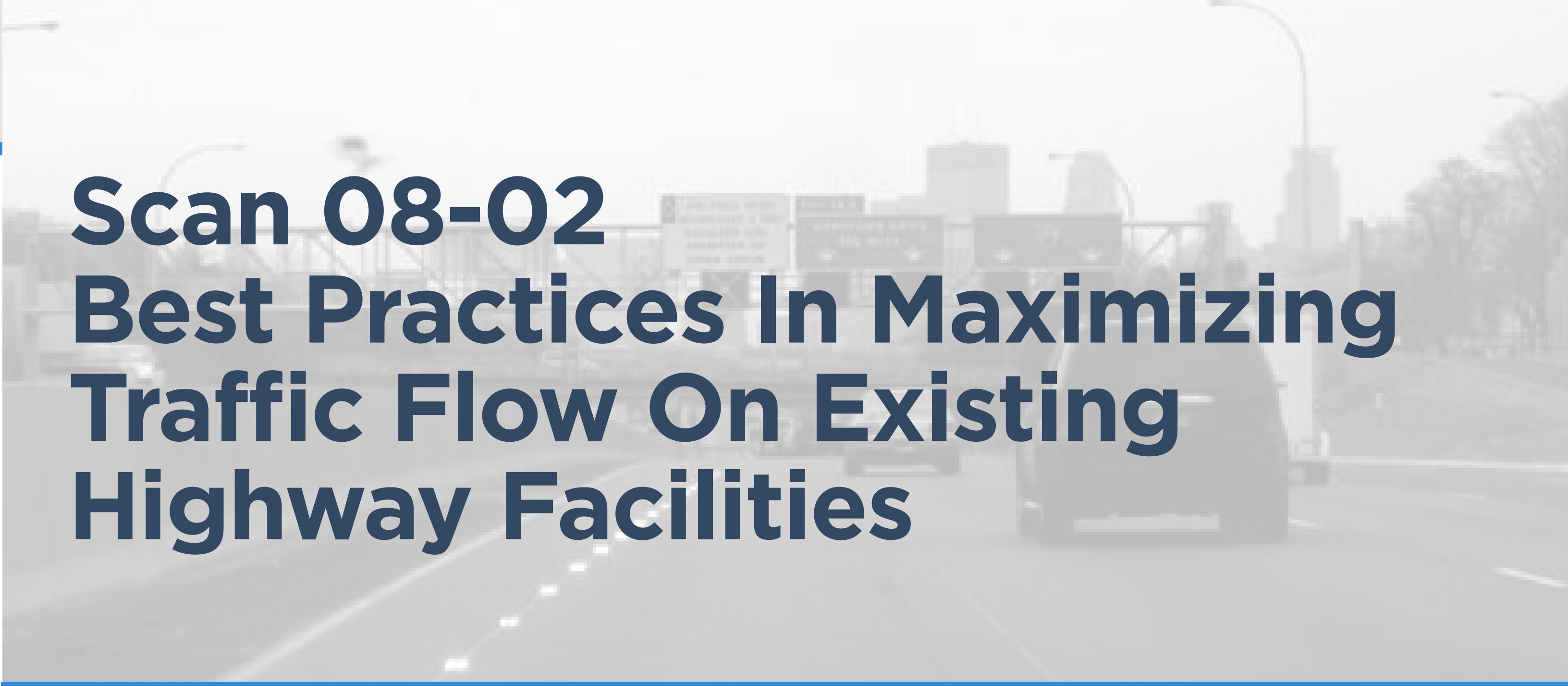
Disclaimer

The information in this document was taken directly from the submission of the authors. The opinions and conclusions expressed or implied are those of the scan team and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors. This document has not been edited by the Transportation Research Board.



Scan 08-02
Best Practices In Maximizing Traffic Flow On Existing Highway Facilities

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24/7	24 hours a day, 7 days a week
AASHTO	American Association of State Highway and Transportation Officials
ATCS	Adaptive Traffic Control System
ATM	Automated Traffic Management
BRT	Bus Rapid Transit
Caltrans	California Department of Transportation
CCTV	Closed Circuit Television
CHART	Coordinated Highways Action Response Team
CHP	California Highway Patrol
DDOT	District of Colombia Department of Transportation
DMS	Dynamic Message Sign
DOT	Department of Transportation
ETC	Electronic Toll Collection
FHWA	Federal Highway Administration
FIRST	Freeway Incident Response, Safety Team
FTA	Federal Transit Administration
GP	General Purpose
HAR	Highway Advisory Radio
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
ICM	Integrated Corridor Management
IT	Information Technology
ITS	Intelligent Transportation System
LARTMC	Los Angeles Regional Traffic Management Center
LED	Light-Emitting Diode
LEV	Low-Emission Vehicle
MATOC	Metropolitan Area Transportation Operations Coordination Program
MdTA	Maryland Transportation Authority

MnDOT	Minnesota Department of Transportation
MPO	metropolitan Planning Organization
MPSTOC	McConnell Public Safety and Transportation Operations Center
MSHA	Maryland State Highway Administration
MTA	Metropolitan Transportation Authority
MTC	Metropolitan Transportation Commission
NCHRP	National Cooperative Highway Research Program
NJDOT	New Jersey Department of Transportation
OCTA	Orange County Tolling Authority
PDSL	Priced Dynamic Shoulder Lane
PE	Professional Engineer
PeMS	Performance Measurement System
RAMS	Regional Arterial Management System
RITIS	Regional Integrated Transportation Information System
RIITS	Regional Integration of Intelligent Transportation Systems
RTMC	Regional Transportation Management Center
SANDAG	San Diego Association of Governments
SHRP	Strategic Highway Research Program
SR	State Route
SOV	Single Occupancy Vehicle
STIP	Scan Technology Implementation Plan
STMC	Statewide Traffic Management Center
SWARM	System Wide Adaptive Ramp Metering
TIP	Transportation Improvement Plan
TMC	Transportation Management Center
TOD	Time of Day
TRB	Transportation Research Board
USDOT	United States Department of Transportation

VDOT	Virginia Department of Transportation
VMS	Variable Message Sign
WSDOT	Washington State Department of Transportation

Executive Summary

Domestic Scan 08-02 is being conducted as a part of NCHRP Project 20-68A, the U.S. Domestic Scan program. The program was requested by the American Association of State Highway and Transportation Officials (AASHTO), with funding provided through the National Cooperative Highway Research Program (NCHRP). The purpose of this scan was to survey strategies used in the United States to maximize traffic flow without expanding capacity on existing facilities. The scanning tour took place from November 9 through 20, 2009. The scan team visited Virginia; Maryland; New Jersey; Minneapolis, Minnesota; California; and Washington State. The team also held a Web conference with the District of Columbia Department of Transportation (DDOT). This report presents a summary of the scan team's approach, goals, objectives, findings, and recommendations.

Introduction

Near-gridlock traffic congestion has been front-page news in large metropolitan areas of the United States for at least two decades, and for much longer in major urban areas, like Los Angeles. The long rush-hour delays and increasing vehicle miles of travel are no longer confined to large metropolitan areas and have become economic and quality-of-life issues in medium-sized cities experiencing growth.

The negative impacts of growing congestion are significant. Long and regularly occurring delays for freight and people reduce productivity, making some areas less competitive for new businesses and resulting in local economic impacts. Congestion is high on the list of civic concerns in metropolitan areas where long commutes and roadways queued with slow or stopped vehicles worsen with every passing year. Environmental research also indicates that congestion's negative effects on the built and natural environments are increasing. As more data on climate change and energy consumption becomes available, more emphasis is being placed on reducing congestion. At the same time, stricter regulations to protect the built and natural environments have increased costs and constraints for expanding highways. Recently, congestion levels have dropped slightly because of the sluggish economy and high unemployment rate. However, as the economy recovers and grows, it is expected that congestion will rise once again, consistent with historic trends.

As shown in Figure ES.1, The Federal Highway Administration (FHWA) studies of historical data consistently indicate that less than half of all congestion is attributable to recurring bottlenecks. Adding roadway capacity (e.g., widening freeways) may not resolve nonrecurring congestion related to construction, special events, weather, and incidents such as crashes. These nonrecurring causes of congestion account for approximately 55% of all congestion. Poorly timed traffic signals also contribute to recurring daily congestion in the broad arterial highway networks.

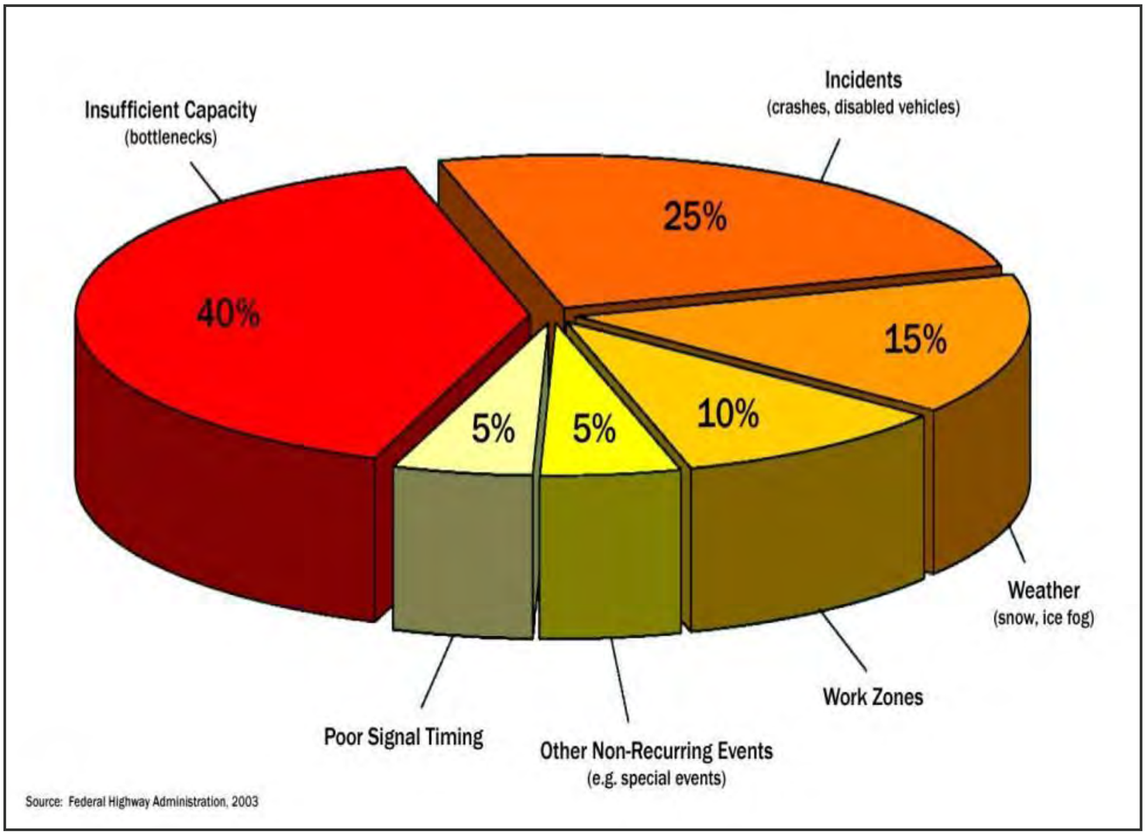

Figure ES.1 ***Causes of traffic congestion***

The rising cost of infrastructure, combined with the growing complexity and controversy of expanding vehicle capacity in urban environments, have increased the value of looking first at maximizing vehicle flow on existing facilities without physically expanding roadway capacity. Advancements in transportation technology have created new options for optimizing traffic flow without building new facilities.

Scan Purpose and Scope

The strong economies of the 1980s and 1990s spurred both job and population growth, which led to the current increased demand for personal mobility and growing vehicle congestion in many metropolitan areas. This inexorable pressure is forcing transportation agencies to consider expanding vehicle capacity on major highways.

As part of environmental clearances such as the National Environmental Policy Act (NEPA)[1] and other project planning processes, transportation agencies are required to consider demand management and system management solutions that might accommodate growing mobility demands without major highway expansion.

These solutions typically are addressed at the regional level and are often considered systematically and linked to air quality conformity. At the project level, these solutions

[1] National Environmental Policy Act, http://en.wikipedia.org/wiki/National_Environmental_Policy_Act

may be given limited consideration. Specifically, system management solutions may be quickly discarded from alternative consideration in favor of expanding capacity. Agencies may not have tools, policies, or processes that allow full and thorough consideration of system management solutions.

This scan reviewed each of the following strategies to maximize traffic flow:

- Use of shoulders as lanes
- Congestion pricing/high-occupancy toll (HOT) lanes
- Traffic smoothing
- Real-time travel management/information
- Coordination of construction activities
- Traffic signal enhancements
- Strategic use of narrow lanes
- Contraflow
- Reversible lanes
- Incident response
- Planning for operations projects
- Performance measures

Details of each strategy are provided is this report.

The scan team was charged with identifying transportation agencies that have successfully implemented several of these types of solutions and documenting their experiences for others to consider when addressing the congestion issues of their own facilities.

Summary of Findings and Recommendations

Current State of the Practice

As a result of discussions that occurred during the scan, the team organized its findings into three classifications of current practices:

- **Common Practices**
  Common practices (i.e., methods, strategies, and technologies) are well tested, have good available guidance, and are used by many urban and urbanizing areas. Many of the agencies visited on the scan tour use many similar methods and practices for improving traffic flow and relieving congestion.

- **Best Practices**
  Best practices are those that are believed to be most effective at addressing congestion (i.e., maximizing flow). The best practices to mitigate traffic flow are carefully planned and implemented with a vision of the future and do not solely focus on current issues.

- **Emerging Practices**
  Emerging practices are new and are being tested in urban and urbanizing areas. Guidance is being developed and performance data is being collected for these practices; follow-up is recommended. As transportation technology matures, it can be applied in new and different ways to maximize traffic flow.

The team found that all of the agencies visited had professionals who are well versed with the strategies listed above. Depending on the specific issue, agency policy, environmental considerations, local constraints, and other governing factors, these agencies have applied many of these strategies to the situations they faced with their own facilities. There was consistency in some of the solutions that were used; some required modification to support the situation in which they were used. In several instances, developing technologies were being deployed. For example:

- **Common practices** include maintaining and supporting intelligent transportation system (ITS) hardware and software systems, including loops and other detection methods, dynamic message signs (DMS), and closed circuit television (CCTV) that allow agencies to broadcast Web- or phone based traveler information (511 systems) and respond to traffic incidents. Many agencies are managing and coordinating work zones on freeways and reporting information through Web-based management systems.

- Considered **best practices**, congestion pricing and managed lane systems have become more prevalent, as they offer reliable travel times in otherwise congested corridors. HOT lanes are the most widely used strategy, as they maintain the incentive for carpooling and transit that were introduced in high-occupancy vehicle (HOV) lanes.

- The advances in traveler information are considered an **emerging practice**. More-detailed real-time traffic information, including transit arrival and various parking management systems, is becoming more easily accessible via a multitude of media. This information is influencing travel choices, including routes and modes. Traveler information is being expanded in places like the San Francisco Bay area to provide the best travel routes customized to meet customer needs. Documenting the benefits or results of traveler information can eventually help agencies better predict and even influence demand because of recurring and nonrecurring events. Another example of an **emerging practice** are Smart Work Zones that incorporate portable traffic management systems and use supporting devices like automated speed enforcement are providing for work zones that are less congested and safer.

The scan team evaluated the current practices it observed in the agencies it visited, organized them into the three classifications discussed above, and developed recommendations for maximizing traffic flow and congestion relief.

Recommendations

After-it had visited the host agencies, the team evaluated owner practices and developed findings for how the agencies used different strategies for maximizing traffic flow. The team's findings-based recommendations are as follows:

- Understand and apply ramp metering **under the proper** circumstances to increase mainline traffic flow and improve safety. Newer systems deploy advanced corridor-based algorithms using real-time data. They also incorporate features such as HOV bypass lanes and freeway-to-freeway metering.
- Use adaptive traffic signal control, which has proven to be effective in maximizing flow on congested arterials. Developing cooperative operations agreements or protocols between multiple jurisdictions for operating traffic signals along arterial corridors has yielded great benefits to regions for the costs involved.
- Use improved traffic incident management systems that integrate transportation agencies and law enforcement for improved response times.
- Use service patrols for incident response to also help reduce recurring congestion.
- Share information between agencies, including prototypical agreements for traffic management concepts and standards, IT communications, publicly developed traffic operations center software, and operational protocols for incident response and ramp metering.
- Spread the cost of development and reduce redundant expenditures by sharing best practices among the traffic operations and management community. Ramp meter software would be a good example.
- Create iconic messages (brands) for agency goals to clarify the relationship and role of efficient operations in managing demand and expanding capacity.
- Improve the understanding of benefits by further developing performance measurement through partnerships among operations/maintenance agencies, planning (metropolitan planning organization [MPO]) and research organizations.
- Emphasize the customers' importance in providing advanced traveler information systems (e.g., 511 systems).
- Foster and develop relationships with private news media. While technology has advanced and Web-based technologies can be used to push travel information, open

and trusting relationships with private news media are also essential to ensure that the broadest audience is reached.

- Deploy a core list of field equipment to serve as the backbone of traffic management systems that manage flow and provide traveler information.
- Ensure that technology maintenance is budgeted and planned into management systems to allow technology to evolve and expand over time.
- Pursue collaboration and coordination among transportation providers (e.g., highway, transit, enforcement, and planning). These partnerships are essential for increasing public trust, improving decision making, and, ultimately, increasing efficiency.

Implementation

The scan team identified several potential dissemination avenues for the results of this scan:

- Publishing articles in magazines and professional journals, including *TR News*[2] and *Research Results Digest*[3]
- Providing AASHTO Web site content
- Making presentations at appropriate AASHTO committee meetings
- Making presentations at regional meeting for state DOTs
- Using the FHWA Web site and other information exchange opportunities
- Conducting webinars
- Making presentations to the Transportation Research Board (TRB) Committee and at appropriate association meetings
- Sharing results using contemporary social media
- Incorporating best practice information into reauthorization initiatives
- Providing a knowledge transfer session (i.e., a webinar) to the host scan agencies
- Sharing best practices with appropriate Strategic Highway Research Program (SHRP 2)[4] researchers and Local Technical Assistance Programs[5]
- Sharing innovations through AASHTO's Technology Implementation Group[6]

[2] *TR News*, http://www.trb.org/Publications/PubsTRNewsMagazine.aspx

[3] Transit Cooperative Research Program Research Results Digests, http://www.trb.org/Publications/PubsTCRPResearchResultsDigests.aspx

[4] Strategic Highway Research Program (SHRP 2), http://trb.org/StrategicHighwayResearchProgram2SHRP2/Blank2.aspx

[5] National Local Technical Assistance Program and Tribal Technical Assistance Program (LTAP/TTAP), http://www.ltap.org/

[6] AASHTO Technology Implementation Group, http://tig.transportation.org/Pages/default.aspx

- Creating and distributing a CD of the best practice findings
- Establishing a peer-to-peer network

A more detailed discussion of these strategies can be found in Implementation Plan.

CHAPTER 1

Overview and Background

Domestic Scan 08-02 is being conducted as a part of NCHRP Project 20-68A, the U.S. Domestic Scan program. The program was requested by the American Association of State Highway and Transportation Officials (AASHTO), with funding provided through the National Cooperative Highway Research Program (NCHRP). The purpose of this scan was to survey strategies used in the United States to maximize traffic flow without expanding capacity on existing facilities. The scanning tour took place from November 9 through 20, 2009. The scan team visited Virginia; Maryland; New Jersey; Minneapolis, Minnesota; California; and Washington State. The team also held a Web conference with the District of Columbia Department of Transportation (DDOT). This report presents a summary of the scan team's approach, goals, objectives, findings, and recommendations.

Background

Roadway congestion is rapidly increasing throughout the U.S. In most cases, building new infrastructure may not be possible due to lack of funds, unavailable right-of-way expansion, or other network constraints. This makes it essential for agencies to maximize safe traffic flow through current roadway facilities by implementing innovative strategies to reduce congestion along the main line and/or network.

The ability to support "mega" infrastructure projects is complicated by their environmental impact and mitigation and by local controversy about where and how projects should be constructed. The construction alone is economically disruptive. Without the influx of recent stimulus dollars, the funding for large infrastructure investments has become an overwhelming constraint for regions suffering from the impacts of congestion. Funding constraints are further exacerbating the increasing need for maintenance and preservation as the amount and complexity of infrastructure grows and the infrastructure ages. As part of budgeting, these needs typically are met before any consideration is given to expanding the transportation system.

As part of environmental clearances such as the National Environmental Policy Act (NEPA) and other project planning processes, transportation agencies are required to consider demand management and system management solutions that might accommodate growing mobility demands without major highway expansion.

Emphasis is beginning to shift away from developing a large infrastructure for providing mobility toward technology and management solutions. This has increased in priority with the recognition that agencies are constrained by the costs and impacts of a large infrastructure and as system management and preservation costs become larger portions of shrinking budgets. While ITS-based solutions (e.g., congestion pricing) have been discussed for the last two decades, real advancements in technology are finally mature and reliable enough to successfully implement.

The team hoped that this scan would initiate the development of a domestic network for peer exchange to gain insights on the best practices, organizational structures, technologies, and lessons learned to catalyze the development of better methods for maximizing traffic flow on existing facilities. This scan provided opportunities for stakeholders to share their experiences with and knowledge of developing regional cooperative agreements, planning, design, implementation, maintenance, and operation of existing highway systems.

The team determined to focus its efforts on the following:

- Investments and solutions that were applied to *existing* facilities, providing a potential point of comparison to operations and safety prior to implementation
- The framework for considering and selecting these types of solutions
- The conditions for optimal operation of these solutions and other lessons learned for successful implementation

From these focus areas emanates the site-selection criteria and process described below, as well as the amplifying questions (see Appendix A) that were used to better understand and ultimately communicate the practices that lead to the best practices in maximizing flow on existing highway facilities. The scan team anticipated that the regions using best practices would have some factors in common, in addition to differences that would be valuable to understand.

In addition to selecting regions that have successfully implemented a variety of strategies, the team wanted to select diverse sites in terms of geography, population size, and maturity. Fundamental to this scan effort was that agencies had applied these strategies to existing facilities in lieu of expanding capacity. System management solutions that may successfully delay or eliminate the need for expanding highway capacity were identified and include:

- Use of shoulders as lanes
- Congestion pricing/high-occupancy toll (HOT) lanes
- Traffic smoothing
- Real-time travel management/information
- Coordination of construction activities

- Traffic signal enhancements
- Strategic use of narrow lanes
- Contraflow
- Reversible lanes
- Incident response
- Planning for operations projects
- Performance measures

The scan team's approach was to look to transportation agencies that had successfully implemented several of these types of solutions.

The team conducted a desk scan (i.e., a literature review) and interviews to determine potential agencies and institutions appropriate for the team to visit. The analysis conducted as part of the desk scan refined the states based on the type and complexity of the solutions, including how the solutions were implemented, what criteria were used in evaluating alternatives, and what adjustments had been made in project selection and implementation based on the lessons learned from the implementation of these strategies. Based on this research, the scan team determined that the following agencies were the best candidates for site visits or web conferences:

- Virginia DOT (VDOT)
- Maryland State Highway Administration (MSHA)
- New Jersey DOT (NJDOT)
- Port Authority of New York and New Jersey (PANYNJ)
- New Jersey Turnpike Authority (NJTA)
- Minnesota DOT (MnDOT)
- California DOT (Caltrans)
- Washington State DOT (WSDOT)
- Washington DC District DOT (DDOT)

Objectives

The scan tour's primary goal was to identify and evaluate current strategies for maximizing flow on existing highways, specifically as an alternative to highway widening to relieve congestion. For this tour, the team looked at strategies for maximizing flow on facilities by using all available pavement and managing it using new technologies and better techniques. With each strategy, the team looked at how performance was measured;

how solutions were prioritized, especially in contrast to capital solutions; innovations in implementation; and lessons learned.

The general objectives of this scan included:

- Identify best practices and the conditions under which each is applicable or best suited
- Identify improvements in planning and design processes
- Recognize that the audience may include traffic engineers, highway designers, ITS operations personnel, and planners

Through the course of discussion and site visits, the team identified organizational constructs and strategies, data development, and software tools that could benefit other agencies. The team also observed specific strategies and their unique design and implementation issues.

Scan Approach

A domestic scanning tour for maximizing traffic flow was established by NCHRP as part of the NCHRP 20-68A, the U.S. Domestic Scan program. The scan team consisted of seven people with expertise in traffic operations, incident response, safety, maintenance, design, and policy. The delegation included representatives from FHWA, AASHTO, state DOTs, and the private sector. (see Figure 1.1).

Figure 1.1 ***Scan team members (left to right): Mark Demidovich, Gregory Jones, Mark Pillsbury, Jeanne Acutanza, Ted Trepanier, Tony S. Abbo, Dan Yacovino (Scan Coordinator from Arora and Associates, P.C.), and Lee A. Nederveld***

The team surveyed seven congested areas to examine techniques used to maximize traffic flow on existing facilities. The scan team agreed that the strategies should:

- Focus on vehicle flow as opposed to movement of people or goods
- Apply to either freeways (i.e., limited-access facilities) or arterial highways
- Be implemented by states or other jurisdictions
- Have discernible benefits if the strategies are part of a larger program
- Have supporting data and information

Ten congestion-relief strategies were identified and selected as the principal alternatives to roadway construction:

- Use of shoulders as lanes
- Congestion pricing/HOT lanes
- Traffic smoothing strategies (i.e., metering and variable speed)
- Real-time traffic management using ITS technologies (ATIS and ATMS)
- Regional coordination of construction activities
- Traffic signal coordination
- Strategic use of narrow lanes
- Contraflow lanes (i.e., lane control signals or movable barrier systems)
- Reversible lanes
- Incident response

In addition, the team researched operations planning practices and the use of performance measures.

CHAPTER 2

Host Agencies

Most tour stops included a visit to the traffic management or operations center that houses traffic operations staff. In some cases, the center also houses maintenance, incident response, emergency response, and/or public information/outreach. All jurisdictions recognized the importance of cross-jurisdiction coordination with emergency responders, maintenance and incident response, and construction management, as well as timely notification of the public by a variety of means. Cross-jurisdiction and cross-state coordination was seen as crucial, with good examples being.

- Transportation Tracking and Communication (TRANSCOM) System[7]
- Metropolitan Area Transportation Operations Coordination Program (MATOC)[8]
- I-95 Corridor Coalition[9], which provides coordination across many East Coast states

The scan topics were most relevant in the most congested regions visited, and the strategies deployed by the transportation agencies were often more regional than statewide. All regions, including most major highways in metropolitan regions around large cities, operate under the operating guidelines of the state DOTs.

The team found that some DOTs have organizational challenges with statewide information technology (IT) agencies regarding ITS applications. Sometimes this creates related challenges with local and statewide IT groups. Jurisdictions noted that roadway infrastructure is much more expensive to build and maintain than hardware/software ITS infrastructure is; however, it has a substantially longer design life. ITS solutions do not usually generate public fanfare (e.g., groundbreaking and ribbon cutting) as roadway construction projects do, yet they require constant maintenance and upgrades to keep current with technology. Nevertheless, they do provide better cost/benefit ratios.

Many agencies are working diligently to communicate to the public that highway capacity expansion is no longer the primary response to congestion. DOTs are attempting to deliver this message directly to the public through focused ad campaigns and branding programs. To communicate its response to congestion, Caltrans developed a mobility system management pyramid (see Figure 2.1) that was recognized throughout this very large and diverse state. WSDOT has branded its Moving Washington logo (see Figure 2.2).

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7 TRANSCOM, http://tcc.doeal.gov/

8 Metropolitan Area Transportation Operations Coordination Program, http://www.mwcog.org/clrp/elements/moits/coordination.asp

9 I-95 Corridor Coalition, http://www.i95coalition.org/i95/Default.aspx

Figure 2.1 ***Caltrans's mobility system management pyramid***

Figure 2.2 ***WSDOT's Moving Washington logo***

Many jurisdictions are creating managed lane networks on freeways that are designed to maximize performance. Managed lane systems are created on existing freeway corridors by applying technology and re-designating lanes. The goals are to improve travel time for high-occupancy vehicles or toll-paying drivers and to collect additional revenue.

The Integrated Corridor Management (ICM) program[10] is developing strategies to manage and integrate freeways, arterials and transit cooperatively within a transportation corridor. These projects, which build on traditional ITS and planning functions, have led to the development of user-based protocols, programs, and interface tools to further improve transportation management center efficiency. Many of these tools can be made available to others as they are developed and refined during this demonstration effort.

Sharing of software and management tools among transportation agencies is one of the most cost-effective and quickest ways to advance the state of the practice in operations. Tools that can be shared and may be useful to a larger agency audience include examples of operational protocol agreements for controlling messages, for incident response and control in the field, and for operations control plans for active traffic management. Additionally, agencies have developed training programs such as the incident response simulation training developed at the University of Maryland.

All agencies are grappling with the collection, sharing, storage, and analysis of traffic data. Many agencies are partnering with research/academic institutions so that collected data can be analyzed to better monitor performance and measure benefits. In some cases, analysis is also helping to refine hours of operation and conditions for use. In California, the mandated partnership between MPOs and Caltrans has resulted in the unique

[10] Federal Highway Administration Research and Technology, http://www.fhwa.dot.gov/research/

development of collected data to support research and monitor/report on performance. The abundance of collected data is allowing more detailed, fine-grained analysis of incidents and traffic flow, including predicting congestion after planned and unplanned events.

Another key partnership for all agencies is their relationship with emergency responders. For all agencies deploying active traffic management, the relationship with emergency responders and law enforcement is critical. Detecting, responding to, and removing incidents and blockages quickly, especially during congested periods, can not only reduce the extent and duration of congestion in the corridor, but also reduce secondary accidents caused by congestion. Clear operational protocols developed among all responders are imperative to ensure that agencies work cooperatively in quickly clearing incidents. Although they are an easy target for budget cuts, service patrols that efficiently clear non-injury accidents provide substantial reductions in congestion resulting from incidents or vehicle breakdowns.

Finally, technology that provides real-time traffic information also supports real-time travel choices. Now that the technology has matured, it is finally able to affect travel demand in a positive way by providing real-time roadway travel comparisons, including information on alternative routes and modes. Advance travel information related to work zones, predicted weather, and other conditions is now available on the highway through highway advisory radio (HAR) and DMS, on the Internet, and on the telephone (i.e., 511 service). The true benefits of having this information, in terms of people who change their travel plans and thereby reduce congestion, are still being studied.

Northern Virginia

Overview

The Northern Virginia District of VDOT manages some of the most congested roadways in the Washington, D.C., metropolitan area. In northern Virginia, there is close coordination between the VDOT region and the headquarters office, as well as with other agencies and jurisdictions.

The McConnell Public Safety and Transportation Operations Center (MPSTOC)[11] , which oversees operations for state facilities in northern Virginia, was built in 2008 and fully occupied in 2009. The agencies housed within MPSTOC include:

- Fairfax County Department of Public Safety Communications
- Fairfax County Office of Emergency Management
- Fairfax County Fire and Rescue Department
- Fairfax County Police Department

[11] McConnell Public Safety and Transportation Operations Center, http://www.fairfaxcounty.gov/westox/mpstoc/

- VDOT Northern Region Transportation Operations Center
- Virginia Department of State Police

A raised supervisor station centrally located within the operations center (see Figure 2.3) allows agencies to work together more cooperatively to more efficiently resolve incidents.

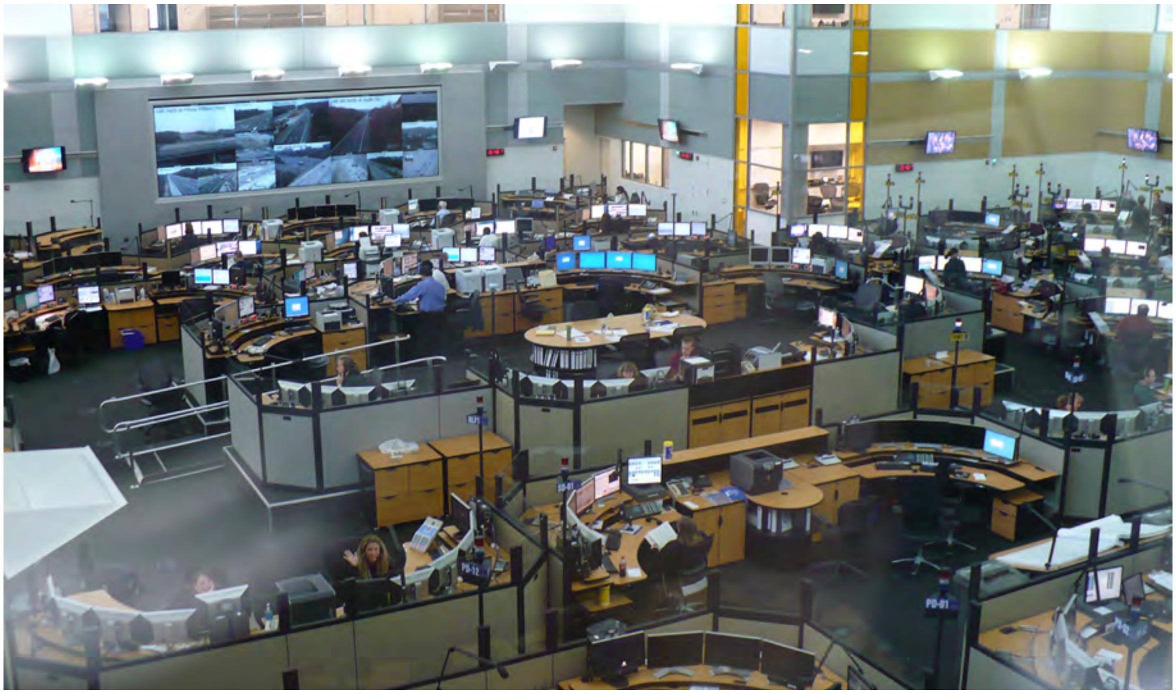

Figure 2.3 ***View of the McConnell PSTOC from the raised supervisor station***

The McConnell PSTOC has reduced bureaucratic barriers, including IT oversight and software/hardware compatibility issues, allowing the center some autonomy. For example, it has defined a "wall" separating state IT functions from the ITS networks, allowing the McConnell PSTOC staff autonomy over hardware purchases and software development. Although no documented boundary defines roles or responsibilities, there is a common understanding of the mission. Staff agreed that leadership and a commitment to the McConnell PSTOC's success were critical, particularly when the congestion relief afforded by the center's efforts is not as high profile as large infrastructure development projects. McConnell PSTOC staff includes traffic operations analysts, who support planning and project development.

Because of its proximity to the nation's capital, security and collaboration with Maryland and Washington D.C. are priorities for the McConnell PSTOC. VDOT participates in the MATOC, which is a coordinated information management system for tracking incidents and road closures throughout the metropolitan Washington region. The McConnell PSTOC also participates in the coordination developed through the I-95 Corridor Coalition.

The relationship created and maintained through MATOC allows for research development and data sharing through the Regional Integrated Transportation Information System (RITIS)[12]. Coordinated by the University of Maryland, RITIS provides real-time transportation data compiled from each of the region's transportation agencies and from other research and data development and analysis functions, including incident after-action plans. Figure 2.4 shows examples of data representations that are available from RITIS.

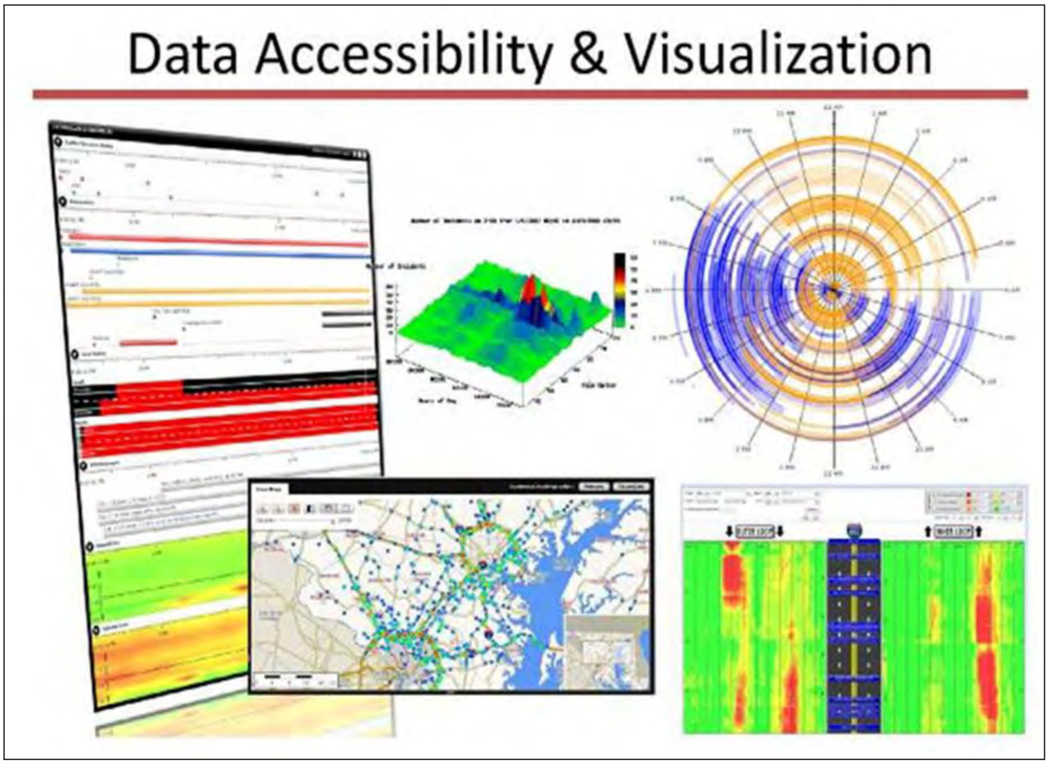

Figure 2.4 ***RITIS analysis***

The McConnell PSTOC staff noted that ITS deployment, including software and hardware (e.g., loops for traffic detection on state facilities), is an area of renewed priority as the agency works to address a backlog of deferred maintenance needs. The center is making progress via programmed modernization and upgrades of critical ITS devices and systems. Programmed funding has been identified to systematically replace and expand ITS components specifically for CCTV, DMS, inductive loops, and other vehicle-detection systems.

Findings

- The McConnell PSTOC, which oversees operations for state facilities in northern Virginia, is a modern facility built in 2008 and fully occupied in 2009.

[12] Regional Integrated Transportation Information System, http://www.mwcog.org/clrp/elements/moits/ritis.asp

- ITS networks allow the PSTOC staff autonomy over hardware purchases and software development.
- MATOC provides a coordinated information management system for tracking incidents and road closures throughout the metropolitan Washington region. The relationship created and maintained through MATOC also allows for the development of research and sharing of data through the RITIS.
- PSTOC staff noted that ITS deployment, including software and hardware (e.g., loops for traffic detection on state facilities) is an area of renewed priority as the agency works to address a backlog of deferred maintenance needs.

Maryland

Overview

Maryland's Coordinated Highways Action Response Team (CHART)[13] is a joint effort of the Maryland DOT, Maryland Transportation Authority (MdTA; an independent agency responsible for tolled facilities), and the Maryland State Police, in cooperation with other federal, state, and local agencies. CHART was established in 1989 as an outgrowth of a public informational campaign called Reach the Beach. Travel to beaches on the state's Eastern Shore is very popular, with high recreational peak direction travel throughout the summer. CHART coordinates with MATOC and RITIS (similar to Northern Virginia). CHART was organized to manage real-time traffic operations on state highways more effectively. The CHART Board includes state, academic, and outreach members.

Mobility is one of six key performance metrics reported to the state. In the future, CHART will expand the 511 system through a private contract to include comparative travel times. CHART is focusing on working with MATOC and RITIS to improve cross-region coordination. CHART incident management performance measures are shown in Figure 2.5.

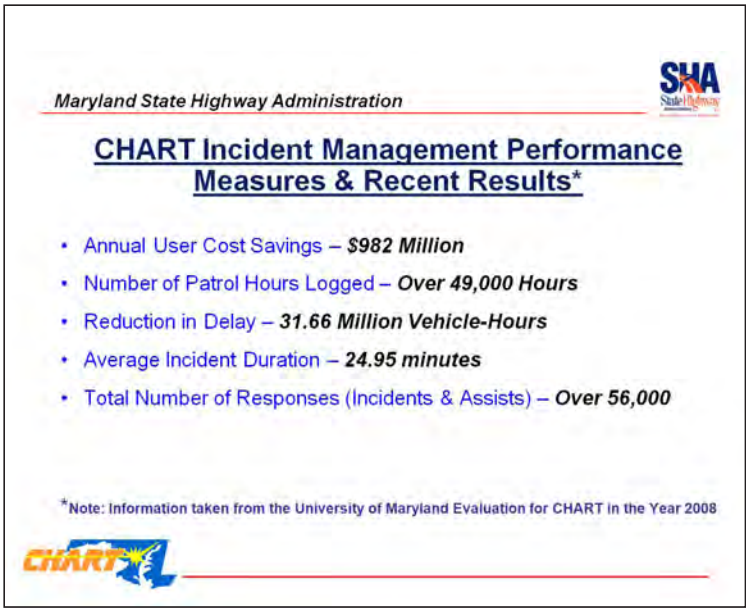

Figure 2.5 ***CHART performance measures and results***

CHART's Hal Kassoff Statewide Operations Center was opened in 1995 as one of six operations centers managing traffic throughout the state. This center is fully staffed 24 hours a day, 7 days a week (24/7); some of the other traffic

12 Coordinated Highways Action Response Team (CHART), http://www.chart.state.md.us/

operations centers in the state are seasonal. The Law Mall Operations Center in Montgomery County is co-located with a 911 call center and helps build trust with enforcement agencies and emergency responders.

MSHA staff members noted that their greatest focus is on safety. As a result, MSHA has developed detailed monitoring of and reporting on incident detection efficiency and effectiveness; response efficiency and duration times; and benefits, including secondary accident reduction, support to motorists, vehicle removal, and overall congestion reduction and travel time benefits. Much of this reporting is done cooperatively through an arrangement between MSHA and the University of Maryland and is available on line[14].

CHART has established unique protocols for control and use of its DMSs by operators at other centers in Maryland.

A primary focus for Maryland has been emergency response and management, including evacuation planning of its Eastern Shore or otherwise related to homeland security. It has maintained its operations systems by upgrading hardware and software as necessary and working closely with the University of Maryland. In support of the I-95 Corridor Coalition, the University of Maryland has been working on a performance audit of vehicle probe use for speed flow data provided by INRIX[15] using Bluetooth wireless technology.

Findings

- Maryland's CHART is a joint effort of the MDOT, MdTA (an independent agency responsible for tolled facilities), and the Maryland State Police, in cooperation with other federal, state, and local agencies.
- CHART was organized to manage real-time traffic operations on state highways more effectively.
- CHART will expand the 511 system through a private contract to include comparative travel times. It is focusing on working with MATOC and RITIS to improve cross-region coordination.

District of Columbia

The DDOT is unique in that it is not governed by a state. Unusual travel characteristics in Washington, D.C., are a high proportion of through trips, a small interstate system, and a large number of daily drivers who live outside the District.

Because the District is at the center of a large metropolitan area, there is a relatively high use of alternative modes of transportation (37% of D.C. residents do not own automobiles, and there are many bicyclists and pedestrians). Much of the congestion is linked to incidents, and mobility goals are centered on people, rather than on vehicles, and emphasize optimizing available capacity (i.e.,

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14 [M]SHA CHART Input and Analysis, http://chartinput.umd.edu/

15 INRIX, http://www.inrix.com/

use the entire pavement). In addition, because the District is also working on livability, arterial highways are being changed to be more pedestrian in scale by adding trees and landscaping.

The District participates in the regional coordination organization MATOC and benefits from the RITIS data analysis and data fusion.

New Jersey

Having a large portion of the residential suburbs of both New York City and Philadelphia located within the state as well as dense urban development have resulted in New Jersey claiming a long history of deploying diverse operational strategies to maximize traffic flow.

Similar to Maryland, New Jersey has separate transportation agencies:

- The New Jersey Turnpike Authority (NJTA) oversees two tolled facilities, the Garden State Parkway and the New Jersey Turnpike.
- SJTPA oversees the Atlantic City Expressway.
- The NJDOT operates and oversees all other state roadways.
- The Port Authority of New York and New Jersey (PANYNJ) is a cross-state organization that oversees tolled facilities (i.e., bridges and tunnels) between the two states.

During the scan, the team visited the NJDOT, the NJTA, and the PANYNJ. The team was also briefed by the local coalition **TRANS**COM.

TRANSCOM

TRANSCOM, a coalition of 16 transportation and public safety agencies in the New York, New Jersey, and Connecticut metropolitan region, was created in 1986 to provide a cooperative, coordinated approach to regional transportation management in 29 counties across the three states. The member agencies include:

- NJDOT
- NJTA
- Connecticut DOT
- New York State DOT
- New York City DOT
- New Jersey State Police
- New York State Police
- PANYNJ
- New York City Police Department
- New York State Thruway Authority
- Metropolitan Transportation Authority
- MTA New York City Transit
- New York State Bridge Authority
- New Jersey Transit Corporation
- Port Authority Trans-Hudson Corporation
- MTA Bridge and Tunnels

TRANSCOM has a significant mission within the region, which is as follows:

> **TRANS**COM improves the mobility and safety of the traveling public by supporting its member agencies through interagency communication and the enhanced utilization of their existing traffic and transportation management systems. Further, as additional systems become available, **TRANS**COM is a forum for ensuring that they are implemented in a coordinated manner.
>
> As a coalition of transportation and public safety agencies, **TRANS**COM serves as a focus for bringing even greater funding into the region to improve regional traffic and transportation management.

While coordination between these agencies has had a long, positive history, it has been tremendously strengthened through their cross-jurisdictional membership in **TRANS**COM. The coalition operates similar to the way MATOC functions in the greater D.C. metropolitan area — in fact, it was the model for MATOC.

TRANSCOM was developed to provide planning and outreach functions, including data development, creation of user interfaces for data collection (e.g., planned work zones), resolution of jurisdictional disputes, and help in reducing redundancies between agencies. TRANSCOM provides oversight and coordination of construction/work zones, incident response, public outreach, and data sharing. It has developed a regional system to share data among 40 operations centers throughout the region and transmit information, including travel times, to the public and other users.

Strategic plans are in place for rerouting traffic to various Port Authority portals to New York City as needed. The New Jersey Institute of Technology and Rutgers, The State University of New Jersey, are conducting ongoing research to help with incident and congestion prediction and planned response.

Findings The United States Department of Transportation (USDOT) cites **TRANS**COM as a good example for other regions and has demonstrated that it is a transferable concept with the institution of MATOC in the Washington, D.C., metropolitan area.

Port Authority of New York and New Jersey

The PANYNJ oversees six interstate crossings that are historically the busiest in the nation, with more than 700,000 trips each day. With this volume of traffic, PANYNJ boasts the busiest exclusive bus facility and deploys a wide range of strategies, including construction coordination, pricing, lane management, and real-time traffic monitoring.

The tragedy that occurred in New York City on September 11, 2001, has shaped and elevated the need for coordinated emergency response. After the events of that day, agencies have reconsidered the control and designation of the Port Authority bridges.

Additionally, as technology has matured, PANYNJ has expanded its use of technology for implementing variable pricing structures, traffic smoothing, and travel information.

Findings PANYNJ deploys a wide range of strategies, including construction coordination, pricing, lane management, and real-time traffic monitoring.

The agency has expanded its use of technology for implementing variable pricing structures, traffic smoothing, and travel information.

New Jersey Turnpike Authority

The NJTA oversees two tolled facilities, the Garden State Parkway and the New Jersey Turnpike. A portion of each highway are dual roadways. The agency works closely with the NJDOT and the PANYNJ for construction coordination and roadway incidents. Active traffic management techniques, including using variable message signs (VMSs) with speed advisories, have been in place for decades as part of the turnpike. These techniques allow the state to better manage its roadways during incidents and optimize flow for freight.

The traffic operations center was recently moved nearer the center of the state from NJDOT's and NJTA's remote locations, enabling the agencies to plan cooperatively how they would work together. It also allowed the NJDOT, the NJTA, and the state police to deploy real-time traffic data to a variety of media.

Findings The NJTA uses active traffic management techniques, including VMSs with speed advisories.

The traffic operations center was moved to a location near the center of New Jersey from the NJDOT's and the NJTA's remote locations.

New Jersey DOT

NJDOT oversees operations on state highways and provides overarching coordination with the NJTA and the PANYNJ. It is co-located with the NJTA in the Statewide Traffic Management Center (STMC) as well as in operating traffic management centers in the northern and southern parts of the state.

Similar to the operations center in northern Virginia, the new operations center has a raised supervisors' console to encourage active and efficient engagement when responding to incidents, regardless of jurisdiction. NJDOT is a member of the I-95 Corridor Coalition and makes use of private speed flow data provided by INRIX. Because the NJDOT has a long history of deploying ITS technologies to address congestion, it is currently addressing aging technology through replacements and technology upgrades. The NJDOT is using private contracts to advance implementation of DMS, CCTV, and detection along corridors.

Findings Using private contracts, the NJDOT is undertaking new projects to advance implementation of DMS, CCTV, and detection along corridors.

The agency encourages active and efficient engagement in responding to incidents, regardless of jurisdiction

Minneapolis-St Paul, Minnesota

Overview

The Minnesota DOT (MnDOT) has been at the forefront of active traffic management development, including fully controlling and managing its highways through ITS deployment, ramp metering, creation of HOT lanes using transponder technology, creation of bus-on-shoulders lanes, and establishing alternative arterial detour routes. MnDOT has benefitted from a strong, focused leadership.

The agency opened its second-generation “Regional Transportation Management Center” (RTMC) in 2003 after a major upgrade from the original 1970 Operations Center. Its 450 CCTV cameras, 5500 loop detectors, 430 ramp meters, 110 VMSs, and more than 150 lane control signals, enable MnDOT to monitor all traffic activity in the Minneapolis-St. Paul metropolitan area. The RTMC maximizes freeway efficiency while minimizing congestion and providing motorist information and incident assistance. The RTMC has the most mature active traffic management system in the U.S. It includes feeds to public outlets and houses commercial radio staff. The information it provides to the public includes information about alternative modes of transportation, including park-and-ride space availability.

MnDOT has converted two of its HOV lanes to HOT lanes in an effort to further reduce congestion and attract motorists to buy in to the facility without compromising service. On I-394, speeds are maintained at 45 mph or above throughout the 11-mile corridor. Vehicles pay to use the HOT lane using the MnPASS[16], which incorporates DMS, lane designation loop detectors, and CCTV cameras. Payment is made electronically using MnPASS transponders. The cost updates every three minutes and varies based on the number of vehicles in the HOT lane, vehicle speed, and traffic conditions. The HOT lanes are available to SOVs that pay for the service; however, carpool and transit vehicles and motorcycles pay no fee. Minnesota State Patrol enforces HOT lane usage. Proximity readers installed in select law-enforcement vehicles are used to monitor the HOT lanes at specific entry locations and throughout the corridor.

Most notably, MnDOT built upon the lessons learned from its ramp metering closures in the 1990s. Legislature involvement and public outcry over perceived long queues and delays at ramp meters led MnDOT to shut off the meters and study the effect on flow. The results strongly supported reinstitution of ramp metering to protect mainline flow. The study also resulted in operational recommendations for ramp metering cycles that enhanced the overall operation.

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16 MnPASS, http://www.mnpass.org/

With the collapse of the I-35W Mississippi River Bridge in 2007, MnDOT has further ramped up its incident response program to be ready in the event of any situation, ranging from a fender bender to a catastrophic failure. Addressing incidents is also important for traffic flow, since incidents cause half of all congestion.

From 5:30 a.m. to 8:30 p.m., Monday through Friday, as many as 11 routes with areas broken into districts have aggressive patrols (Freeway Incident Response, Safety Team [FIRST][17]) ready to respond to incidents. In 2008, FIRST responded to nearly 13,000 incidents; the average arrival time is 9.1 minutes from the receipt of a call. FIRST is improving both response and clearance times.

Findings

- MnDOT has been at the forefront of developing active traffic management, including fully controlled and managed highways through ITS deployment, ramp metering, HOT lanes using transponder technology, creation of bus-on-shoulders lanes, and establishing alternative arterial detour routes.
- MnDOT opened its second-generation RTMC in 2003 after a major upgrade from the original 1970 Operations Center. The upgrade included additional CCTV cameras, loop detectors, ramp meters, VMSs, and lane control signals, resulting in improved monitoring capability and traffic activity in the Minneapolis-St. Paul metropolitan area.
- MnDOT built on its experiences with ramp metering closures in the 1990s through extensive studies, which led to enhanced overall operations.
- With the collapse of the I-35W Mississippi River Bridge in 2007, MnDOT has further ramped up its incident response program to be ready in the event of any situation, from a fender bender to a catastrophic failure.

California

Overview

California DOT (Caltrans) hosted visits to three urban regions of the state:

- San Francisco Bay metropolitan area, hosted by Caltrans District 4
- Los Angeles metropolitan area, hosted by Caltrans Districts 7 and 12
- San Diego metropolitan area, hosted by Caltrans District 11

The team noted the benefit of coordinating planning activities with operations activities throughout the scan tour. This relationship was formalized in California through Senate Bill 45, which allocated 75% of transportation project funding to MPOs and 25% to the state (Caltrans). This policy ensures that planning organizations and Caltrans work together in

[17] Freeway Incident Response, Safety Team, http://www.dot.state.mn.us/rtmc/first/index.html

planning and implementing transportation solutions. As a result, a close partnership was created throughout the state between the planning agencies, which coordinate solutions and respond to growth, and Caltrans, which maintains and operates state facilities and interstates, the backbone of the transportation system.

Solutions in California are not one-size-fits-all and have regional practicality. Most notably, HOV lanes in southern California operate and are designed differently than those in northern California. Caltrans has a chief information officer who advocates for technology and helps eliminate barriers to support operations and ITS solutions.

Caltrans is unified in its messaging regarding transportation investment priorities. It developed the System Management Pyramid, branding a unified perspective that prioritizes system monitoring and preservation, smart growth, ITS, operational improvements, and judicious system completion and expansion. Project staff emphasizes environmental project evaluation criteria that include energy use, sustainability, and social equity.

California has benefited from ICM and Urban Partnership Agreement[18] project awards. As a result, Caltrans and its partner planning agencies are developing coordinated, technology-rich expressway systems. The Bay Area HOT network (expressway system) is depicted in Figure 2.6.

Similar to other agencies on the scan tour, Caltrans and its partner planning agencies are developing performance measures to support efficient multimodal infrastructure investments. The Freeway Performance Measurement System (PeMS)[19], a joint project with the University of California, Berkeley, is a model for accessible data collection, development, and provision. Mature ITS systems and technology advancements are allowing transportation agencies to provide real-time travel route and travel mode choices.

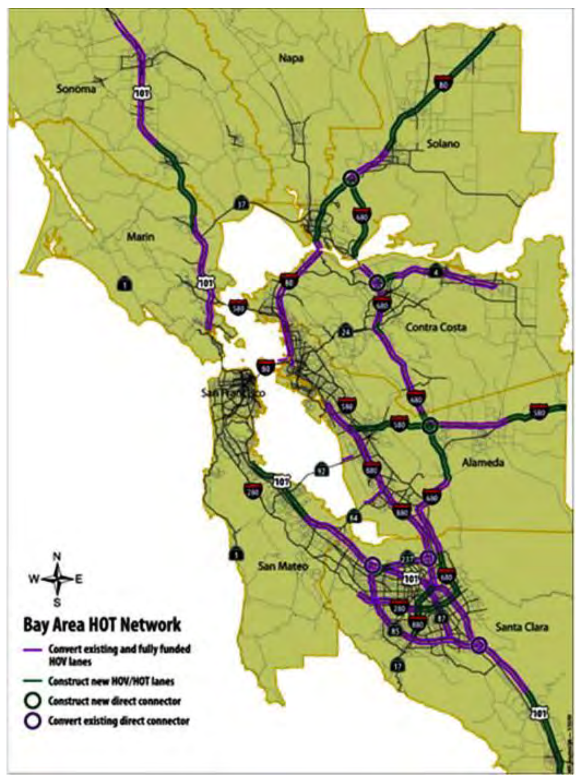

Figure 2.6 ***Caltrans HOT expressway system***

Oakland

Caltrans District 4 in Oakland is working with the Bay Area Toll Authority and other planning and transit agencies to develop and establish an 800 mile expressway regional managed lane network. It also has a project along I-80 that

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[18] MnDOT Congestion Relief on I-35W, http://www.dot.state.mn.us/upa/

[19] Performance Measurement Software. PeMS is a trademark of Caltrans, the University of California, Berkeley, and PATH, the Partnership for Advanced Technology on the Highways. A fact sheet on PeMS can be found here: http://www.siemens.com.co/SiemensDotNetClient_Andina/Medias/PDFS/439_20080304181922.pdf

has been involved in the ICM demo program and is now looking to integrate active traffic management in this corridor.

The Metropolitan Transportation Commission (MTC) has developed information systems that integrate available travel information and provide extensive on-line information, including real-time comparative and customizable travel times. System development plans that are being evaluated extend beyond the freeway and include arterial systems.

Los Angeles

Caltrans District 7 (Los Angeles) and Orange County (District 12) have long histories dealing with congested freeways. Like other areas in Caltrans, they, too, are working with their planning agency and transit provider partners to develop solutions that will maximize flow and increase personal mobility without requiring large freeway expansions.

District 12 includes State Route 91 (SR 91), the country's first HOT lane project, which was completed in 1995. Orange County was able to provide the team with its lessons learned, which included how the project has evolved since it opened. The Los Angeles metropolitan area, including Orange County, has a well-developed freeway system that operates at near saturation for extended periods of the day. HOV lanes with some barrier or buffer separation are operated 24/7 and are present on most freeways.

District 7, and its regional partner L.A. County Metro, will be implementing the first pricing project in Los Angeles. It is a federal Congestion-Reduction Demonstration Initiative[20] project that will convert existing HOV lanes on two major urban routes to HOT operation in 2012.

San Diego

Caltrans District 11 covers the San Diego metropolitan area. The staff has a strong partnership with the MPO covering San Diego, the San Diego Association of Governments (SANDAG)[21]. Agency staff noted both its emphasis on making decisions effectively and the benefits of strong leadership that will champion technology initiatives. Its project development process typically has favored large infrastructure projects rather than taking advantage of operational-based projects like ITS. Thanks to SANDAG's prioritization process and goal of moving people, funding for ITS and technology fares well.

There are fewer agencies in District 11 than in other metropolitan areas (i.e., only one county, one transit agency, and one Caltrans District), which makes coordination simpler, with less competition and bureaucracy. San Diego's planned expressway system is shown in Figure 2.7.

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[20] Intelligent Transportation Systems Joint Program Office, Congestion Initiative, http://www.its.dot.gov/congestion/index.htm

[21] San Diego Association of Governments, http://www.sandag.org/

Figure 2.7 ***San Diego area expressway plan***

Findings

- Senate Bill 45 allocated 75% of transportation project funding to MPOs and 25% to the state (Caltrans), prompting planning organizations and Caltrans to work together when planning and implementing transportations solutions.
- California has benefited from ICM and UPA project awards, as transportation agencies need to work together in solving regional issues.

Seattle, Washington

Overview

In the Seattle metropolitan area, WSDOT provides management and oversight of state facilities, including interstates, through close cooperation with local agencies and planning organizations. Similar to Caltrans, WSDOT has developed a simple logo, Moving Washington (see Figure 2.2) to illustrate its reliance, in equal parts, on efficient operation, demand management, and the strategic addition of capacity.

WSDOT has developed *The Gray Notebook*[22] , a quarterly performance report that is mandated at the highest level of the agency. WSDOT staff also noted the importance of public involvement and engagement that support project and program implementation.

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[22] *The Gray Notebook*, http://www.wsdot.wa.gov/NR/rdonlyres/44BEDB99-6AF7-42BA-A0BF-1EE412004186/0/GrayNotebook_March_2011.pdf

WSDOT has been successful in implementing innovative solutions, including its loop detection, DMS, and cameras, and ramp metering. WSDOT has implemented a successful HOT lane in addition to a regional network of HOV lanes. WSDOT has utilized a successful program of operational projects through their "Q Funds" program.

Findings

WSDOT has been successful in implementing innovative solutions, including its loop detection, DMSs, and cameras, and ramp metering. WSDOT has implemented a successful HOT lane in addition to a regional network of HOV lanes. WSDOT has utilized a successful program of operational projects through their "Q Funds" program.

INRIX

While in Seattle, Washington, the scan team visited the headquarters of INRIX, a private developer and provider of real-time traffic information. The company uses a mix of "probe" vehicles, loop detection data from agencies, and other mobile devices.

INRIX is currently providing real-time speed and congestion information to several states along the East Coast through a contract agreement with the I-95 Corridor Coalition. It also mines data from loops provided by public agencies and coordinates with some agencies when incidents are detected or loops are malfunctioning. The data is evaluated, prioritized, and fused prior to its release.

Like other private data developers, INRIX has a tremendous amount of speed data on freeways and is close to being able to provide similar speed data on arterial streets. INRIX does not provide volume data.

CHAPTER 3

Observations and Key Findings

The wealth of information provided by the host agencies is presented in this section. Each strategy is presented in location-specific discussions, followed by their planning, performance measures, and lessons learned.

Strategies for Maximizing Traffic Flow

The scan tour reviewed the 10 congestion relief strategies outlined in Overview and Background (listed again below). Details of each strategy are provided in this section.

- Use of Shoulders as Lanes
- Congestion Pricing/HOT Lanes
- Traffic Smoothing
- Real-Time Travel Management/Information
- Coordination of Construction Activity
- Traffic Signal Enhancements
- Strategic Use of Narrow Lanes
- Contra flow lanes
- Reversible lanes
- Incident response

Use of Shoulders as Lanes

Overview

The purpose of shoulder lanes is to improve safety by providing a lane for motorists involved in incidents or whose vehicles have broken down; law-enforcement activities also occur in the shoulder of many roadways. While shoulders provide safe refuge, they also consist of large expanses of impervious surface. With the idea of using every inch of pavement, agencies have considered using shoulders to address short congestion periods or making them available for use by professional drivers only (i.e., buses).

The agencies indicated that they still take into account design issues (e.g., acceleration distances for high-speed facilities) and have been successful by using dynamic signs and unique pavement color when only segments of the shoulder will be used for travel. As described in the next section, VDOT has successfully implemented shoulder use on I-66 to address peak directional congestion. Freeway shoulders have a unique coloring to differentiate the part-time shoulder lanes from the full-time general-purpose (GP) lanes and are accompanied by dynamic overhead signs.

VDOT

Since I-66 opened in 1993, use of shoulder lanes has been permitted during weekday commute peak periods. The lanes are six miles long and generally 12 feet wide. The lanes have full-depth pavement structure and a contrasting top pavement color to differentiate them from other travel lanes. In addition to the pavement coloring, the lanes have overhead changeable signs (i.e., a red X when the lane is closed for use and a green arrow when it is open), supplemented with static signs noting use and time (see Figure 3.1). VDOT is considering adding a yellow angled arrow to transition traffic when the shoulder lane is closing.

Figure 3.1 ***I-66 shoulder lane***

The times designated for shoulder use have been studied and adjusted/expanded based on speed flow detector data. Because the shoulder does not function as a breakdown lane in the peak direction during peak periods, it is imperative that breakdowns be cleared quickly.

VDOT also opens the shoulder lanes to traffic if needed when incidents or construction activities block a GP lane. It is considering expanding the shoulder lanes' operating hours further to include weekends when recreational traffic creates congestion.

Findings

- Lanes are six miles long and generally benefit from being 12 feet wide.
- Contrasting top pavement color aids in differentiating the shoulder lane from other travel lanes.
- It is imperative that breakdowns be cleared from shoulder lanes quickly.
- Shoulder lanes have overhead changeable signs to delineate when they are in service.

Caltrans: San Diego

Caltrans is developing a transit-only bus-on-shoulder system project on I-805. The goal of this project is to provide a travel lane that would allow bus rapid transit (BRT) to operate with free flow conditions that would allow expedited and dependable travel times for the BRT system. In addition, there could be the potential to sell some excess capacity to private commercial vehicles with trained drivers (e.g., United Parcel Service).

This BRT facility could be developed to demonstrate some of the advanced features being developed as part of the Connected Vehicle Research initiative[23], including vehicles with intelligent cruise control, to maximize lane efficiency. Drivers' capabilities could be enhanced through in-vehicle warning systems and equipment to help them stay within the lane. A two-year pilot program was initiated at a cost of between $50 million and $55 million. It avoids bridge and outside widening and is consistent with long-range plans for HOV expansion in this corridor. BRT operation will increase ridership and potentially gain revenue (through commercial use) to invest in the corridor.

There are challenges to using shoulders as travel lanes though. They include the need for design exceptions, safety concerns for clearing the shoulders prior to use as a travel lane, and limited pathways for emergency responders coming to incident scenes. Although both outside and median shoulders were considered for use, the median shoulders were selected due to reduced conflicts at access.

Findings

- Providing a preferential use lane for transit vehicles can provide incentives to use a BRT system by providing quicker and dependable travel times.
- Shoulders may offer a possible option for a preferential travel lane, but they have design challenges as well.

[23] Connected Vehicle Research, http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm

NJDOT

NJDOT is using a two-mile shoulder section of a spur on the Newark Bay Bridge, converting a full-width shoulder to reduce queues in the morning and evening peak periods. While traffic is not highly directional, the additional lane provides congestion relief. NJDOT may restripe it for full-time use with the next bridge deck replacement/reconstruction.

Findings

NJDOT is currently using a two-mile shoulder section of a spur on the Newark Bay Bridge to provide shoulder lanes.

PANYNJ

A shoulder segment of I-495 is signed for HOV3+ and buses from the morning peak (7 to 9 a.m.). The lane, which approaches the George Washington Bridge heading toward Manhattan, has special signs and traffic control devices. After 9 a.m., permitted buses can use the shoulder.

Findings

A shoulder segment of I-495 is signed for HOV3+ and buses during the morning peak to help reduce congestion on the approach to the Lincoln Tunnel. Buses continue to use it the remainder of the day to improve traffic flow.

MnDOT

MnDOT has three different types of shoulder use applications. The first is temporary use of shoulders during peak travel periods. One application using this technique is a broadly developed Bus Only Shoulders (BOS) network that operates on 260 miles of freeway during peak travel periods. The system has been in place for nine years and has had substantial accident analysis. The BOS network has been developed at low cost and provides the twin benefits of travel time reliability and increased transit ridership. One of the major benefits of the increased reliability is that with increased schedule adherence, there is less need to keep buses positioned on standby, thus freeing them for scheduled service. Bus drivers must complete training, and buses using the shoulder can only operate at a maximum speed of 35 mph and not more than 15 mph over adjacent travel lanes.

The second type of shoulder use was to take an existing shoulder and use it as a bottleneck remedy. In response to congestion along I-35W, a three-mile segment of shoulder was used to create an extended travel lane to accommodate a merge. This new capacity lane resulted in reduce queuing and congestion.

The third type of shoulder use is the priced dynamic shoulder lane (PDSL), which is discussed in more detail in Congestion Pricing/HOT Lanes.

Findings

MnDOT successfully employs three different types of shoulder use applications:

- Temporary use of shoulders, primarily by buses, during peak travel periods
- Priced dynamic shoulder lanes (PDSL)
- Take an existing shoulder and use it as a bottleneck remedy to give a spot treatment of increased capacity

Caltrans: Los Angeles

Time-of-day shoulder use was employed to improve operations and safety at the freeway-to-freeway ramp from the northbound Pasadena freeway (SR 110) to I-5 north of downtown Los Angeles. The left GP lane adjacent to the ramp drop lane is allowed to access the connector by using the ramp's right shoulder only during the afternoon peak period, increasing capacity and throughput at this interchange. Additional widening is not possible due to the presence of a historic bridge. The ramp is further constrained due to tight turning radii, resulting in a lower per-lane capacity (1800 vehicles per hour) that does not meet the peak demand of 2500 vehicles during the peak hour. Queues have resulted in rear-end accidents and long queues.

The extra lane is created using DMS and in-pavement light-emitting diode (LED) markers. Smartstuds[24] provide illumination by induction cable, which is in the pavement; The studs can be changed out as part of a maintenance cycle without tearing up pavement. By changing lane designations during peak hours, the connector road ramp-to-ramp volume to capacity ratio is improved to 0.91, which means the connector road is able to provide enough capacity to the existing traffic demand. . The shoulder lane is in use from 3 to 7 p.m.

Findings

Caltrans employs time-of-day shoulder use to improve operations in Los Angeles.

WSDOT

WSDOT is using shoulders to address peak congestion. A new bottleneck was created on US 2 when an upstream capacity improvement released demand and created a new demand at a gore area (see Figure 3.2).

Figure 3.2 ***Shoulder use on US 2***

[24] Smartstud is a registered trademark of 3i Innovation Ltd. http://www.3iinnovation.com/smartstud-5/

WSDOT took enhancement funds to restripe the roadway to create a time-of-day use shoulder lane, which was augmented with signs, to meet peak demand. Studies after the lane was opened indicated some violations in the time period leading up to the peak period as the roadway becomes congested; however, travel speeds have increased and are more reliable.

Findings

WSDOT implemented shoulder use to address peak congestion.

Congestion Pricing/HOT Lanes

Overview

Pricing facilities has long been a strategy for encouraging use of alternative modes and managing transportation capacity as a "supply" with an elastic value. Historically urban areas (e.g., northern New Jersey, including connections to New York City by PANYNJ) have long applied pricing or tolls to higher performing facilities.

Technology has improved through electronic tolling that eliminates tollbooths and pavement sensors that detect speeds. Through these innovations, agencies that implemented express facilities and HOT lanes for HOVs found that they could "sell excess capacity." Challenges have included how to control these systems without excess new and expensive infrastructure to control access. Barrier-less systems are being used with transponders in Washington State and Minnesota, and both agencies include unique channelization at HOT lane entrances.

VDOT

The I-495 beltway in northern Virginia is currently under construction to build two new HOT lanes in each direction that will feature open road/transponder tolling technology. A similar venture is under consideration for the existing HOV lanes on the I-395/I-95 corridor. These projects are being developed as design-build-and-operate by private concessionaires overseen by VDOT. The agency noted that there will be a need for oversight and coordination between the HOT lanes being managed by the private sector and the adjacent GP lanes being operated by VDOT.

Findings

I-495 beltway in northern Virginia is currently under construction to build two new HOT lanes in each direction that feature open road/transponder tolling technology. These projects are being developed as design-build-and-operate by private concessionaires overseen by VDOT.

WSDOT

WSDOT has implemented two tolled facilities in the state using E-ZPass[25] transponders. The first, on the Tacoma Narrows Bridge, was as a public/private venture to pay off bonds. The second, on SR 167, converted an existing HOV lane to HOT, and allows SOV users to pay a toll electronically to use the lane. The HOT lanes were well publicized. Thorough outreach with local agencies' technical and policy staff, as well as community groups, resulted in a general acceptance of the HOT lanes. On SR 167, HOVs travel free. Tolls range from $0.25 to $8.00 and are adjusted based on demand. The lane is separated from the GP lanes by a double solid white line except in merge zones.

Tolling is being considered to finance a number of facilities, as well as provide priced reliable travel speeds and travel advantage for HOVs.

Findings

- WSDOT has implemented two tolled facilities in the state using electronic transponders.
- HOT lanes were well publicized. Thorough outreach with local agencies' technical and policy staff, as well as community groups, resulted in a general acceptance of the HOT lanes.

NJTA

The New Jersey Turnpike and Garden State Parkway are tolled facilities with established fees. The PANYNJ has crossings between the two states that are all tolled:

- Goethels Bridge
- Lincoln Tunnel
- George Washington Bridge
- Holland Tunnel
- Bayonne Bridge
- Outerbridge Crossing

A new crossing, the CORE project, will also use tolls.

Tolling has primarily been used as a funding source for infrastructure. The tolling systems have migrated to incorporate electronic toll collection (ETC), in this instance E-ZPass transponders, the common technology used along the I-95 corridor in many northeastern states. ETC is performed on these facilities using both dedicated tollgates and high-speed transponder readers to relieve congestion at their toll barriers.

Discounts are allowed for HOV 3+; however, these HOVs lose some of the travel time benefits because they need to wait in toll operator lanes to acknowledge the

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[25] E-ZPass is a registered trademark of the Port Authority of New York and New Jersey, http://www.e-zpassiag.com/ (home page for The E-ZPass Group)

occupancy. There are also discounts for low-emission vehicles (LEVs). Tolls are linked to the Consumer Price Index and are increased consistent with changes in the index. Discounts are provided with higher use and may encourage, rather than discourage, travel. Elimination of these discounts is under consideration.

Findings

- New Jersey Turnpike and Garden State Parkway are tolled facilities with established fees that utilize ETC to relieve congestion at their toll barriers.
- The PANYNJ has several crossings between the two states that are all tolled and utilize ETC to relieve congestion at their toll barriers.

MSHA

MdTA and MSHA are currently constructing the InterCounty Connector, probably one of the most significant and high-profile highway projects in Maryland. This 18-mile, six-lane, limited-access toll facility will link existing and proposed development areas between the I-270/I-370 and I-95/US 1 corridors within central and eastern Montgomery County and northwestern Prince George's County. This will be a toll facility with variable tolls based on congestion conditions.

MdTA is also developing new express toll lanes on I-95 north of Baltimore in 2011 that will be exclusively open road tolls. Lanes will have DMS and CCTV on bridges and tunnels. Within the tunnels will be detection for stopping or crossing the centerline and use of weather sensors to alert drivers of freezing conditions, although snow removal is a high priority. MdTA also uses photo radar enforcement in work zones.

I-95 north of Baltimore is currently a tolled facility that uses both E-ZPass and several cash tolls. Tolls are collected to fund infrastructure investment, not to manage congestion. Current E-ZPass use is 30 to 72% and provides a frequent-user discount that *encourages* travel. Although toll violations for out-of-state license plates are a challenge, they are being resolved through cross-jurisdictional license reporting[26].

MSHA is studying several major corridors across the state, including the I-270 and the Capital Beltway (I-495) corridors in the metropolitan Washington region, as potential managed-lane facilities. Along I-270, strategies being evaluated include HOV lanes; express toll lanes; HAR, detection, and CCTV; and alternative high-capacity transit corridors (BRT and light rail transit). To address current and short-term needs, there is increased project emphasis on improving operations by making low-cost high-benefit minor geometric improvements to the existing system to improve the existing system's efficiency. Innovations include parking availability notification within the corridor to promote ridesharing/transit. A regional model is being developed to evaluate the interrelationship

[26] MDTA Toll Facilities, http://www.mdta.maryland.gov/TollFacilities/facilities.html

of demand and capacity. A statewide transportation model has been developed to evaluate future transportation needs from a travel demand, networks, and policy context.

Findings

- Tolls are collected to fund infrastructure investment, not for managing congestion.
- To address current and short-term needs, there is increased project emphasis on improving operations by making low-cost high-benefit minor geometric improvements to the existing system, thereby improving existing system efficiency. Innovations include parking availability notification within the corridor to promote ridesharing/transit.

MnDOT

MnDOT has two corridors utilizing congestion pricing: I-394 and I-35W. The first is an 11-mile long system, three miles of which is a closed two-lane reversible facility. The remaining eight miles are concurrent flow one-lane converted HOV lanes that are now tolled and opened in 2009.

The second corridor, I-35W, is a 16-mile-long system that is being developed in three segments, including conversion of HOV lanes for use as a HOT facility, construction of a two-mile segment extending HOT lanes, and PDSLs entering downtown Minneapolis. This project is being developed through an Urban Partnership Agreement project. Tolling is collected by motorists using transponders. Tolling is collected from motorists electronically through MnPASS transponders; the amount varies by time of day (TOD). Service in HOT lanes is set at 45 mph (90% of the time). Access for non-HOV vehicles will close if 45 mph speeds cannot be maintained. Rates are adjusted dynamically and vary from $0.25 to $8 per trip, depending on demand and congestion; updates occur every three minutes. All revenues are returned to these corridors. Unique entry and exit designs were developed to accommodate tolling and safely allow access (see Figure 3.3).

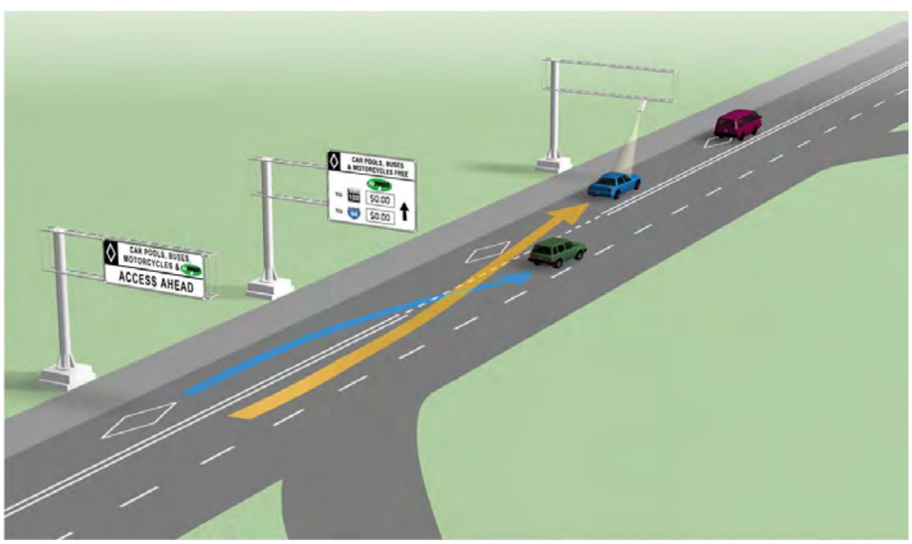

Figure 3.3 ***Access area, MnDOT***

On the I-35W price dynamic shoulder lane (PDSL), the transition to the beginning of the shoulder lane is enhanced by a section of in-pavement LED lighting. These lights are being evaluated for their effectiveness in all weather conditions as part of the demonstration project. Enforcement for these facilities uses Raytheon mobile detection equipment[27] to ensure that transponder usage is appropriate. A mobile inquiry may prompt law enforcement to pull over a vehicle to test if an SOV has a transponder that is not turned on or if a transponder has not registered a payment. While many transponders are deployed, only a third of them are used on any given day, indicating that they are only used when drivers desire a travel time benefit. Other benefits of this solution include reduced congestion, improved safety, lower HOV violation rates, and a self-sustaining system (i.e., tolls support development, maintenance, and operations).

Findings

MnDOT has two corridors utilizing congestion pricing. I 394 is an 11-mile long system, three miles of which is a closed two-lane reversible facility, and eight miles is concurrent flow, one-lane converted HOV lanes that are now tolled and opened in 2009. The second HOT lane was opened on I-35W.

Caltrans: Oakland

A collaborative effort led by the MTC has helped define the completion of an 800-mile regional express system with a managed lane/road pricing concept. The system will utilize 500 miles of existing and funded HOV lanes and 300 miles of new lanes and convert them to managed lanes using tolls. This system will be implemented in a phased approach. Large projects are currently authorized on I-680, SR 237, I 580, and SR 85. The concept allows for 24/7 operation and manages the lane through occupancy requirements and dynamic pricing that will be enforced by the California Highway Patrol (CHP). Roll out of the Expressway system will begin with projects on I-680, I-880/SR 237 and I-580.

A separate project on Antioch Dumbarton Bridge is considering a range of tolling options that includes tolling carpools. Legislation is under consideration that would make carpools pay as part of tiered system.

Findings

Caltrans is planning to utilize a congestion pricing/HOT lanes approach on an 800-mile regional express system with a managed lane/road pricing concept in the Oakland area. The system would utilize 500 miles of existing and funded HOV lanes and 300 miles of new lanes and convert them to managed lanes using tolls.

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[27] See http://www.raytheon.com/capabilities/products/htms/proj/index.html#mndot for Raytheon's description of this project.

Caltrans: Los Angeles

Opened in 1995, SR 91 is a four-lane, 10-mile tolled expressway connecting Riverside and Orange Counties. The project was funded through a private sector partnership using innovative financing constructed by the California Private Transportation Company, LLC. The project was funded with a 35-year franchise agreement and built within the center median of the existing public freeway.

The managed lane portion of SR 91 is two lanes in either direction, physically separated from the GP lanes by pylons. There are no intermediate access points along the 10 miles. SR 91 was the first toll expressway in the state. Others were proposed, of which, one is currently under construction in northern California.

Four service patrols are dedicated to the managed lane to remove disabled vehicles. However, if need be, CHP can enter the facility to support and clear express lanes. In emergencies, express lanes can be closed or opened to all traffic with no tolls.

A noncompete clause in the original agreement prevented any improvements within the corridor until 2030. In 2003, the Orange County Tolling Authority (OCTA) purchased the facility at a price of $207.5 million to remove this noncompete clause and allow reinvestment in the corridor. Since then, $11 million has been reinvested in the corridor. The OCTA put in place an advisory committee that meets every two months.

Triggers to adjust tolls are based on OCTA Toll Policy based on available capacity (demand) and the effect of incremental toll increase. OCTA has published static toll rates that are revisited every six months and vary by TOD and day of week (see Figure 3.4). These rates apply to the full 10-mile trip and allow no intermediate access to the barrier-separated facility. Maintenance of the barrier pylons is an issue but necessary to maintain a physical separation that is flexible in nature. Since 2003, evening tolls have increased substantially; however, the morning peak has not increased as quickly. Travel time savings are between 45 and 60 minutes per trip and are well understood by customers. Traffic volumes have decreased since peaking in 2007.

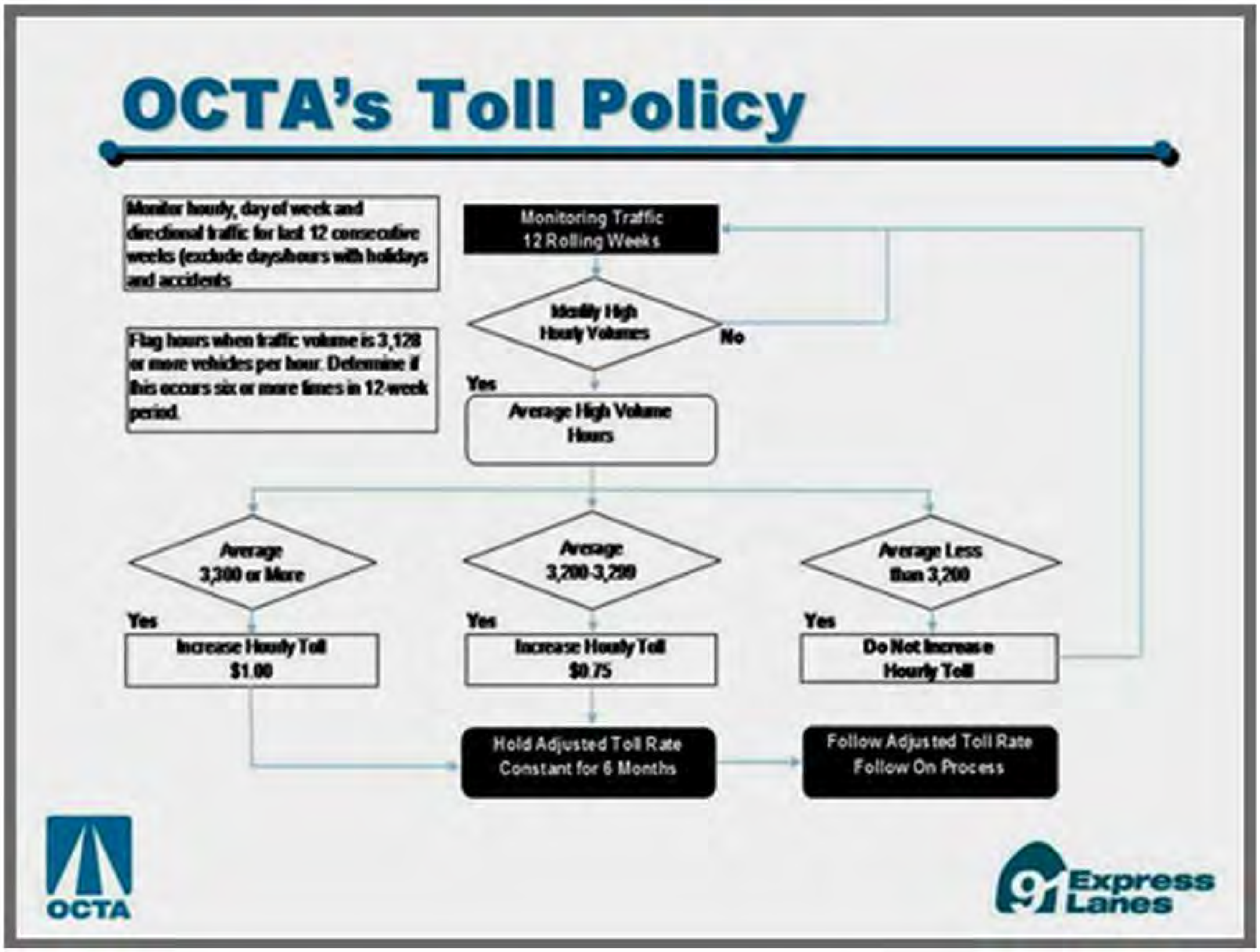

Figure 3.4 ***Caltrans SR 91 toll policy***

A 10-mile expansion further into Riverside County is under consideration. Points of debate for the expansion have been the financial burden the entire trip would impose and if there should be intermediate access points to allow for access on shorter or less costly trips.

Notably on SR 91, toll lanes move 1,500 vehicles per lane per hour for three to four hours in each peak direction. Caltrans has found that these lanes tend to move more vehicles than the GP lanes since they are managed to maintain reliable travel speeds of 55 mph or higher, while the GP lanes tend to break down with congested conditions. While they can carry up to 2000 vehicles per lane per hour at their maximum flow, GP lanes often carry much less traffic once the flow breaks down and congestion sets in.

The OCTA operations center for SR 91 coordinates with Caltrans operations centers and uses in-pavement detection at half-mile intervals, CCTV, and content management system. OCTA is also looking at managing travel demand and developing a parallel BRT facility. Additionally, HOV 3+ vehicles get a discount (i.e., they do not always travel free). Spotters enforce the 3+ occupancy. To encourage HOV 3+ use, tolls on Thursday afternoons are half price. The process for adjusting tolls is based on demand.

Working with LA Metro, Caltrans is implementing congestion pricing for the first time on the Los Angeles freeway system, through the conversion and expansion of the Harbor Freeway I 110 and the El Monte Busway (I 10) HOV lanes to tolled HOT facilities. USDOT awarded this project to the L.A. region, with a total project cost of $290 million. This is a USDOT Congestion Reduction Demonstration project,[28] with an expected opening in the summer of 2012. The project also includes transit enhancements and service. For the 11 mile I 110 Harbor Freeway, two HOV lanes in each direction (built in the mid-1990s) between Adams and 182nd Street will be converted to HOT. The 15-mile El Monte Busway within the I-10 right-of-way will be converted to HOT between I-605 and Alameda Street. Other elements of the project include:

- Steps to attract ridership include transit expansion (20% of the project), including purchase of buses, improved service, and 100 vanpools. The project will leave the occupancy as it currently is (i.e., 3+ on the El Monte and 2+ on I-110). The project will implement an open road tolling with dynamic pricing, enforcement areas, and dedicated tow trucks and CHP patrols. On the El Monte Busway, access will not change; however, a second HOT lane will be provided, and removing buffers will enable spot widening. On the Harbor I-110, the ramps for Adams and Figueroa will be modified to improve access and cut wait time in half. All vehicles must have transponders, even those registered as HOVs. There will be switchable transponders and supplementary lights on overhead gantries for visual confirmation of payment. Caltrans is also looking at license plate photo enforcement.
- An express park portion of the project that makes up 5% of the project's cost. It will provide information on parking availability through a Web site, DMS, and mobile devices. The city of Los Angeles will manage a study of parking usage in the downtown area and may provide guaranteed parking from the initiation of the ride.
- Half of the project costs will provide transit facility and station enhancements, including at the El Monte Bus Station, to the light rail transit linkages along I-110, and to security and lighting.

This project is unique among the currently operating HOV-to-HOT projects in the United States, in that there is very little capacity to sell to drivers willing to pay a toll. In most cases across the U.S., agencies have used pricing as a means to address under-utilization of existing HOV lanes. In Los Angeles, the existing HOV lanes are nearly at their capacity during the peak periods. In fact, the HOV facility on I-10 (the El Monte Busway) is one of the most successful HOV lanes in the country, carrying half of the person-throughput in the corridor already.

In order to implement pricing, the Los Angeles Partners have come up with strategies to maximize existing capacity and create additional capacity. The additional capacity

[28] Los Angeles County Congestion Reduction Demonstration National Evaluation Plan, http://www.upa.dot.gov/docs/fhwajpo10016/chap2.htm

is being achieved by adding one additional lane (within the existing right-of-way) and modifying the termination points of the HOT lanes to mitigate end-of-facility queuing. To maximize existing capacity, Caltrans is integrating transit as viable tool in achieving mode and temporal shift (i.e., encouraging travel outside typical commute hours).

Approximately 70% of the project budget is being invested in transit, including:

- Purchasing new buses
- Providing expanded and additional bus services, including new service connecting both corridors
- Expanding capacity of transit stations and commuter rail station
- Improving security along bus routes
- Expanding vanpool service
- Constructing a new bus plaza to allow buses to enter the existing terminal directly from the HOT lane
- Constructing a new bus maintenance facility
- Expanding transit signal priority on city streets connecting to freeway corridors
- Implementing a SMART parking program in the city of Los Angeles, with incentives for Express Lane users

These strategies are focused on making transit a more reliable, safer, accessible, and attractive option for commuters traveling these corridors. The result should be more capacity to sell to those willing to pay for it, ultimately improving mobility by moving more people, not cars.

Part of the Expressway plan will create “green corridors” that will reduce fuel consumption and manage speeds to an optimal 45 to 55 mph range using variable speed signs. The Metro board has adopted flow speeds of 45 mph as being safe and reliable. Expressways will guarantee performance of no less than 45 mph and will provide credits if this performance is not achieved. Hybrid vehicles will no longer receive free access to tolled facilities. Tolls will range from $0.25 to $1.40 per mile, resulting in a $19 maximum cost for an end-to-end trip on the I-10 El Monte and $14 for an end-to-end trip on I-110. Funding from the project will be used to rehabilitate the I-10 El Monte Busway, including upgrading detection, CCTV, and toll collection technology.

Senate Bill 1422 requires that an evaluation of impacts to low-income populations along the freeway corridors be performed. As a result, Caltrans is considering providing a toll or transit credits for low-income users to encourage them to use carpools, vanpools, or transit in lieu of SOVs. A stated preference survey will be used to provide baseline information for this population.

Outreach and public education will be important for this project's success. One potential issue being analyzed is how to improve the flow at the termini of the HOV lanes. The El Monte Busway has been very successful, and it carries half the people in the I-10 corridor in fewer lanes.

Findings

- SR 91, a 10-mile tolled expressway opened in 1995, saves between 45 and 60 minutes of travel time per trip.
- The SR 91 toll lanes move 1,500 vehicles per lane per hour for three to four hours in each peak direction. These lanes tend to move more vehicles than the GP lanes since they are managed to maintain reliable travel speeds of 55 mph or higher.
- The El Monte Busway on I-10 in Los Angeles is an exampe of the successful use of HOV lanes, carrying half of the person-throughput in the corridor.
- To maximize existing capacity, Caltrans is working with LA Metro to integrate transit as a viable tool in achieving mode and spatial shift (i.e., encouraging travel outside typical commute hours).

Caltrans: San Diego

The MPO has developed a long-term expressway plan for the San Diego area covering five routes. The first of these is the I-15 Expressway between SR 163 and SR 78, which is a managed-lane facility and consists of three segments to be implemented in three phases. The first middle segment was completed in March 2009. Typical dynamic signs displaying price are shown in Figure 3.5.

The north segment will be completed in 2011, and the south segment will be completed the following year. The managed toll lanes will be completed with a BRT project. This project was the first to be completed using Grant Anticipation Revenue Vehicles (GARVEE) bonds[29]. The operational criterion for the lanes is to maintain a Level-of-Service C and allow vehicles to pay in to achieve a travel time advantage. HOVs are free and are not required to carry transponders.

Figure 3.5 ***I-15 tolling information display***

[29] Caltrans Grant Anticipation Revenue Vehicles (GARVEE) Bond Program, http://www.dot.ca.gov/hq/innovfinance/garveebond.htm

In the future, all vehicles may be required to carry transponders and put in a shield when they are HOVs.

The facility includes new direct access to park-and-ride stations. Intermediate barrier breaks two to three miles apart allow access in and out. The facility is all open road tolling. DMSs note costs to specific locations with travel times.

Other management techniques include in-pavement lighting and controlled zipper gates and pop-up delineators controls. The traffic management center uses automated, computerized cameras and software sequences for the gates and pop-ups closing lanes. Trained staff operates short segments of moveable barrier daily (similar to the ones used on the Coronado Bridge) . Other corridor enhancements have included transit enhancements, like expanded express bus service and increased carpool parking.

Overall benefits of the 16-mile managed lanes includes reduced congestion and increased ridesharing/transit use[30]. Innovations being used include pony bridges and design sequencing to expedite construction. Infrared detection to check vehicle occupancy is being considered for use.

Findings

- Congestion management pricing is helpful in achieving public sector goals in the San Diego region. Developing an operational criterion, in this case to maintain a Level of Service C in managed lanes and allow vehicles to pay in to achieve a travel time advantage is important.
- In the San Diego area, Caltrans applied a variety of technical approaches are available for use in congestion pricing/HOT lanes, including:
  - Direct access ramps to park-and-ride stations
  - Intermediate barrier breaks two to three miles apart to allow intermediate access in and out
  - Open road tolling
  - DMSs that note costs to specific locations with travel times
  - In-pavement lighting
  - Zipper gates
  - Pop-up delineators
  - Moveable barrier
  - BRT

[30] Keep San Diego Moving, a resource for TransNet Early Action Projects status and updates, http://www.keepsandiegomoving.com/home.aspx

Traffic Smoothing

Overview

Traffic smoothing strategies are one of the most effective means of maintaining the capacity of limited-access facilities, such as interstates. Ramp metering that manages access onto limited-access facilities has long been used to reduce congestion related to merging, weaving, and diverging. MnDOT has a long, successful history of justifying ramp meter benefits. In some states, ramp metering was installed with bypass lanes to provide travel time benefits for HOVs and transit. These bypass lanes are being revisited as agencies weigh the travel time benefits against the conflicts created by unmetered traffic.

VDOT

Ramp metering at 24 locations has been part of I-66 and I-395 for 15 years as a way to prioritize the main flow of traffic. Ramp meters often use a fixed-time plan with two-second red and two-second green. While not prevalent on other northern Virginia interstate roadways, recent VDOT studies indicate that ramp metering is effective in keeping mainline traffic moving and improving overall freeway performance. These studies persuaded VDOT to extend ramp meter operating hours for the peak direction and begin metering traffic in the off-peak direction as a way of reducing off-peak congestion. Furthermore, VDOT used micro-simulation tools to evaluate more advanced ramp metering algorithms. Adaptive metering was shown to offer significant congestion relief benefits over fixed-time operation. VDOT plans to integrate the fixed-time and adaptive ramp control into the statewide Advanced Transportation Management System (ATMS) platform, OpenTMS Enterprise System.

Findings

- Metering at 24 locations has been part of I-66 and I-395 for 15 years as a way to prioritize the main flow of traffic using ASSIST software
- Recent studies by VDOT indicate that ramp metering is effective in keeping mainline traffic moving and improving overall freeway performance.

NJTA

The New Jersey Turnpike has 150 variable speed advisory signs accompanied by advisory signs that have been in place for 40 years. Unique to New Jersey is the development of protocols for reducing speeds in weather conditions. Certain fog levels and visibility reductions guide the posting of lowered speeds or even roadway closure.

Findings

New Jersey Turnpike has 150 variable vehicle speeds/speed advisory signs accompanied by advisory signs that have been in place for 40 years. These signs have been tremendously useful in providing facility users with advanced warning of road and traffic conditions ahead.

PANYNJ

PANYNJ has used access metering on the Manhattan side of the Holland Tunnel to help meter peak-period traffic entering the tunnel from the east (see Figure 3.6). The metering was intended to increase flow into the tunnel and has resulted in reduced congestion and crashes.

Findings

Ramp metering was intended to increase flow into the tunnel and has resulted in reduced congestion and crashes.

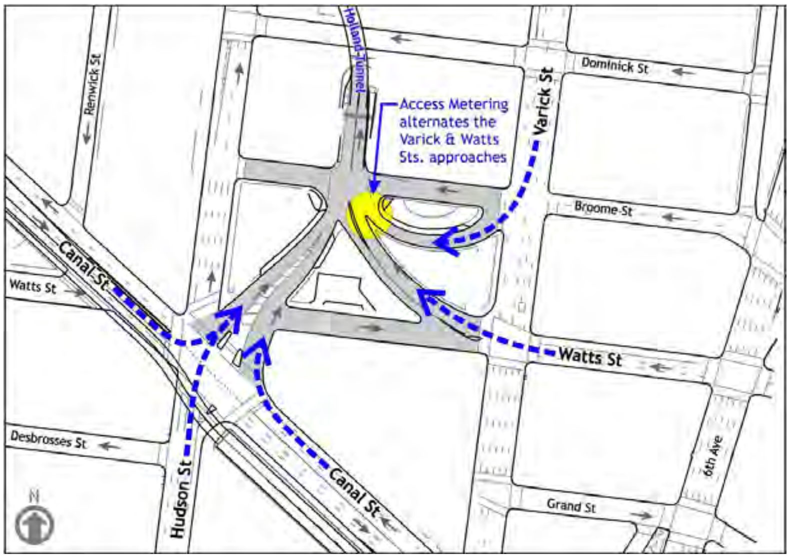

Figure 3.6 ***Access metering from the Manhattan side of the Holland Tunnel***

MnDOT

MnDOT has applied active traffic management, including variable speed signs, DMS, and lane closure signs using over-lane gantries. MnDOT has more than 430 ramp meters in use. The legislature shut down the ramp meters in 2000, and a subsequent study compared freeway operations with and without ramp meters. The results showed dramatic benefits from ramp meter usage, including significant benefits over operational costs. The study results also lead to some operational changes in the way the meters were used (e.g., setting a maximum upper delay limit of four minutes at service interchanges and two minutes at system interchanges). MnDOT does not meter in the nonpeak direction.

The current metering protocol uses adjacent lane detection and changes to green at 2.8-second intervals, then yellow, and then red. The system dumps when the delay approaches four minutes. Some ramp meters allow bus bypass along bus shoulder lanes. The operations window for ramp meters is 6 to 8 a.m. and 2 to 6:30 p.m. Ramp meters can also be used to manage upstream and downstream congestion during incidents.

MnDOT undertook an arterial alternative detour project, including deployment of dynamic guidance signing on arterial signal mast arms. The intent of the project was to coordinate potential detouring between freeway and arterial systems in the event of closures or blockages. The project included arterial travel time assessments. Lack of equipment upkeep by local agencies led to the project's abandonment.

Findings

- MnDOT study results showed dramatic benefits from the use of ramp meters
- The study results also led to some operational changes in the way the meters were used, such as setting a maximum upper limit of delay of four minutes at service interchanges and two minutes at system interchanges.

Caltrans: Oakland

Ramp metering on corridors such as US 101 have demonstrated the benefits of ramp metering. As part of the I-80 Active Traffic Management project, anticipated to be in place by 2015, the I 80 corridor will include ramp metering and variable speed limits. The Alameda County Congestion Management Agency[31] has conducted detailed analysis of the anticipated performance of ramp metering. Overall reduced delay and improved travel times resulting from ramp metering would indicate high benefits over cost and a strong return on investment as part of active traffic management. The agency has completed a concept of operations for its active traffic management deployment.

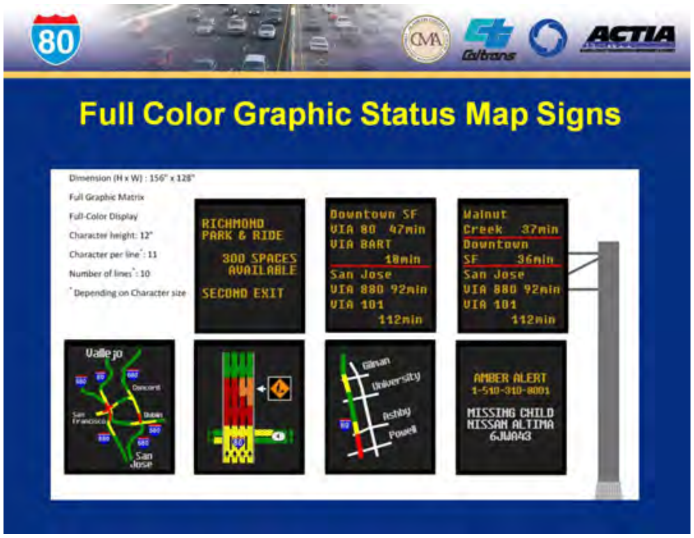

Figure 3.7 ***Full-color matrix signs***

Anticipated signing for the active traffic management on the I-80 corridor will make use of full-color matrix signs to provide broader traveler information (e.g., routes and maps) (see Figure 3.7).

[31] The Alameda County Congestion Management Agency, http://www.accma.ca.gov/pages/index.aspx

Findings

Overall reduced delay and improved travel times on Oakland highways resulting from ramp metering suggests high benefits over cost and a strong return on investment.

Caltrans: Los Angeles

Caltrans District 7 implemented the first ramp meter in California in 1967. The district currently operates more than 950 ramp meters and 19 freeway connector meters. These meters operate in a traffic-responsive mode, which means that they adjust rates based on conditions in the adjacent mainline traffic lanes.

In 2006, Caltrans initiated a project to implement ramp- and connector-metering strategies to relieve congestion on the I-210 corridor in eastern Los Angeles County. The I-210 Congestion Relief Project primarily focuses on the development and implementation of enhanced on-ramp and freeway-to-freeway connector metering strategies, including:

- Addition of 41 traffic-responsive ramp metering at nonmetered on-ramp locations
- Addition of 24 microwave vehicle detection stations along remote sections of Rte 210
- Installation of nine connector meters at major freeway-to-freeway interchanges
- Conversion of previously nonmetered HOV bypass lanes to metered GP or HOV bypass lanes at 32 locations throughout the corridor

In addition, Caltrans implemented System Wide Adaptive Ramp Metering (SWARM) along the eastern segment of the corridor. This advanced metering strategy works by evaluating real-time traffic situations at selected bottlenecks throughout the corridor to predict future congestion and properly set upstream metering rates, thereby helping to reduce congestion throughout the corridor (see SWARM illustrations in Figure 3.8 and Figure 3.9). SWARM has various algorithms that allow it adjust meters based on downstream bottlenecks, available storage in the adjacent freeway segment, or on a desired headway spacing. In this way, SWARM responds to both recurrent and nonrecurrent congestion.

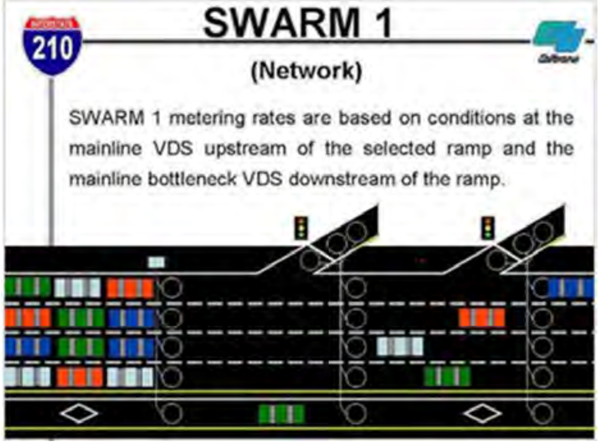

Figure 3.8 ***Ramp metering algorithm***

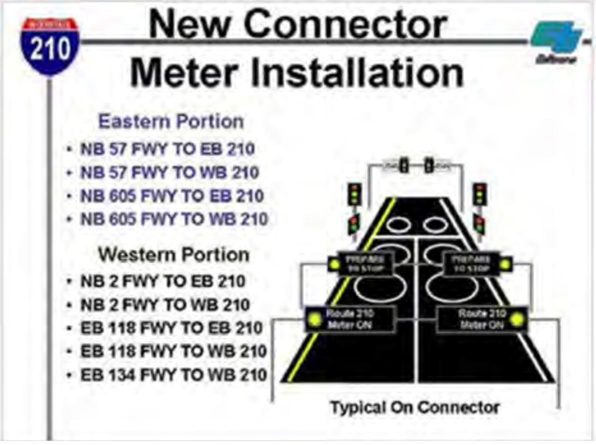

Figure 3.9 ***Freeway-to-freeway ramp metering***

This project was completed in 2008 at a cost of $20 million. The project has provided benefits in reduced congestted periods and shorter travel times, resulting in reduced emissions.

Findings

- Caltrans District 7 has long experience with ramp metering, having first implemented ramp meters in 1967.
- Caltrans implemented SWARM along the eastern segment of the I-210 corridor to:
    - Evaluate real-time traffic situations at selected bottlenecks throughout the corridor
    - Predict future congestion and
    - Properly set upstream metering rates thereby helping to reduce congestion throughout the corridor

Caltrans: San Diego

The goals of ramp metering are to reduce congestion, improve safety, reduce energy consumption, and reduce delays. Ramp meters are in place on most of the regions interstate system. In general, they all have HOV bypass ramps, and most operate based on algorithms that automate operations, including shutting down when congestion is low; Caltrans is moving toward SWARM-style algorithms. Evidence strongly supports that ramp metering is successful in reducing congestion. Ramp metering is guided by a 50-page Ramp Meter Design Manual[32] prepared by California Department of Transportation.

The SANDAG Regional Arterial Management System (RAMS)[33] is an inter-jurisdictional traffic signal coordination effort as part of the Southern California Priority Corridor "Showcase" Project. RAMS was initiated in 2003 with the objectives of developing corridor-level signal coordination and remotely managing signal timing. RAMS architecture utilizes QuicNet/4[34] software. The program coordinates over 3,000 traffic signals across 20 agencies, with a regional interface with Caltrans. The QuicNet program allows remote management of traffic signals, including retiming and modification. The project has been piloted at three jurisdictions, with the plan to roll out the remaining 14 locations in a second phase. Data is integrated into an intermodal transportation management system.

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[32] California Department of Transportation Ramp Meter Design Manual http://www.dot.ca.gov/hq/traffops/systemops/ramp_meter/RMDM.pdf

[33] SANDAG Regional Arterial Management System, http://www.sandag.org/index.asp?projectid=49&fuseaction=projects.detail

[34] QuicNet/4 is a product of BI Tran Systems, Inc. A brief overview of QuicNet/4 and BI Tran can be found here: http://tsi.0catch.com/specs/quicnet.pdf

Findings

- Evidence strongly supports that ramp metering is successful in reducing congestion on highways in the San Diego area.
- The application of ramp metering in Caltrans District 11 is guided by a 50-page ramp meter manual.

WSDOT

WSDOT has had regulatory (and enforced) variable speed limits for 15 years on I-90 and more recently on US 2 through mountain passes that are subject to snow, icy conditions, and avalanches. These variable speed limits work in conjunction with changeable message signs, HAR, and a seasonal operations center. The primary benefit is up to a 30% reduction in weather-related crashes.

WSDOT recently installed variable speed limits on I-90 in the urban areas of Seattle as a way of managing flow. It has a mature ramp metering system in the urban areas of Puget Sound. Most urban freeways include ramp metering; of these, most have unmetered HOV bypass lanes for transit and carpools.

Policy does not support freeway-to-freeway ramp metering. Ramp-metering algorithms are developed using adjacent loop data and are activated based on lane density. Ramp meters were evaluated to assess their effect on local streets and were found to reduce arterial street queues as overall operations on the mainline of SR 520 improved due to metering.

In November 2010, WSDOT constructed active traffic management on I-5, I-90, and SR 520 that consists of variable speed limits and overhead lane control with changeable message signs on overhead gantries (see Figure 3.10). These will augment the existing cameras, loops, and DMS in place in these corridors and will be used to manage congestion, incidents, and work zones. On SR 520, this is an interim measure until tolling and a planned bridge replacement project replaces the facility with added HOV capacity.

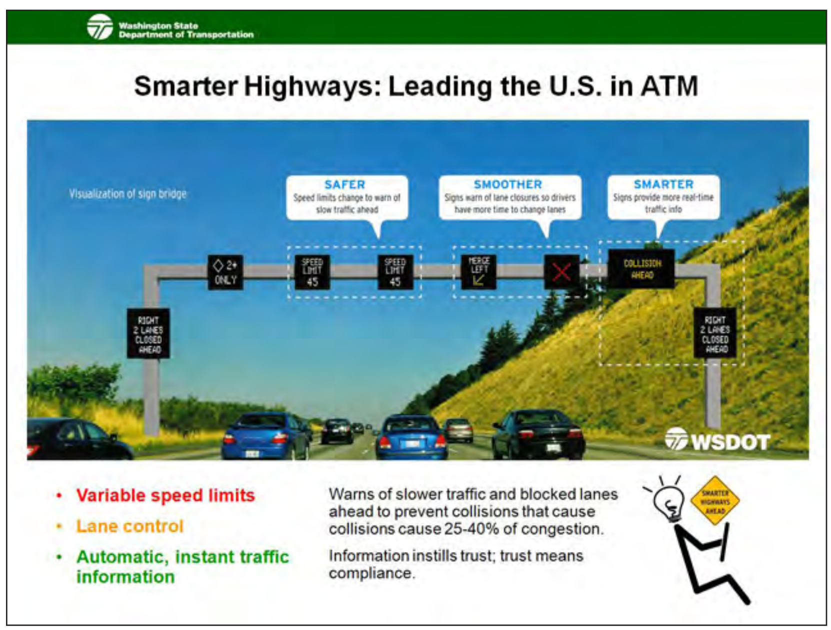

Figure 3.10 *Active traffic management*

Findings

- Variable speed limits work in conjunction with changeable message signs on WSDOT facilities.
- WSDOT evaluated ramp meters to assess their effect on local streets. The agency found that the meters reduced arterial street queues as overall operations on the mainline of SR 520 improved due to metering.

Real-Time Travel Management/Information

Overview

Providing route and mode choices and upcoming congestion or incidents and to traveler's handheld devices and roadside devices is very appealing to the motoring public. As the technology has matured, motorists see this information as essential. Caltrans in the Bay Area has the most mature 511 information system in the country and is creating new and innovative applications of traveler information, including subscription to comparative travel times.

VDOT

Through a pilot project and in cooperation with a major destination retail center (Tysons Corner Center[35]), VDOT funded and developed an interface of traveler information for mall patrons. Information is displayed throughout the mall on large plasma screens and includes traffic congestion information; transit routes, times, and fees; work zones; and other travel alerts. The project was coordinated with other public outreach and was well received, with mall employers desiring similar information.

Findings

VDOT implemented a traveler information pilot project in cooperation with a major destination retail center in northern Virginia that was well received locally. The project was coordinated with other public outreach.

DDOT

DDOT has an established ITS and operations center that relies on detection, cameras, and changeable signs supported by CapTOP software. The initial phase of ITS deployment identifies congestion hotspots and provides real-time traffic information through a variety of media. The next phase of ITS deployment was scheduled in 2010 and included new DMS, cameras, and count locations. It utilizes privately available (INRIX) speed and flow data.

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[35] Tysons Corner Center, http://www.shoptysons.com/

Findings

- DDOT has an established ITS and operations center that relies on detection, cameras, and changeable signs.
- The next phase of ITS deployment, scheduled in 2010, included new DMSs, cameras, and count locations.

NJDOT/NJTA

The STMC is the major operations center in the state supported by two minor operations centers. It also houses the database for the Statewide Information for Travelers. A data manipulation tool, trumpit[36] , takes INRIX historical incidence data and provides information to the public, including to handheld PDAs. It also feeds the 511 system, including the Web page (http://511nj.org/). An example of data collected for travelers is shown in Figure 3.11. Information is provided along one-mile segments for customer ease of use.

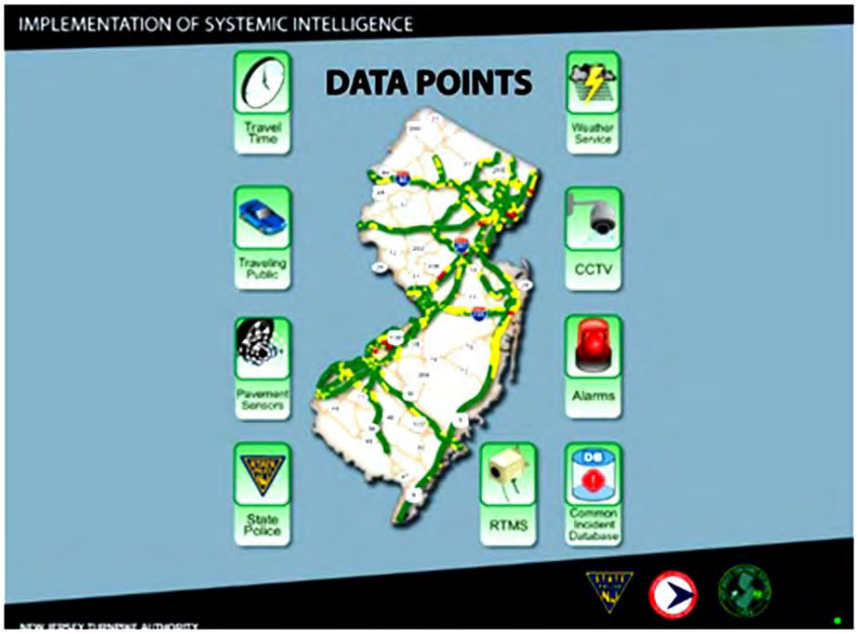

Figure 3.11 ***Traveler information***

Co-located agencies (i.e., NJDOT, NJTA, and the state police) have access to speed/congestion maps, weather data, and cameras. The STMC's activities include incident response, construction management, congestion management, detours, closures, weather event monitoring, and state patrol dispatch for both the NJTA and NJDOT jurisdictions. Turnpike loop detection is not reliable and is not used to develop speeds. Speed flow data are provided from private data providers (INRIX) for freeways; however, INRIX data are not available for arterial roadways.

[36] Trumpit is a trademark of HTNB; http://www.trumpit.org/index.html

New full-color signs are being used for trailblazing, along with hybrid (drum message) signs, that can guide traffic to any one of the New York access points. The 511 program, Twitter and other Web-based social media provide users with real-time traffic information. In the future, 20 to 30 new CCTV/DMS installations are planned per year on the state system.

Findings

- The 511 program, Twitter, and other Internet-based social media are used to provide users with real-time traffic information.
- Co-located agencies (i.e., NJDOT, NJTA, and the state police) have access to current speed/congestion maps, weather data, and cameras to more effectively manage incident response, construction , congestion , detours, closures, weather event monitoring, and state patrol dispatch for both the NJTA and NJDOT highways.

MnDOT

The operations center houses state patrol emergency response and computer-aided dispatch and provides information for travelers via MnDOT's AM radio broadcasts on KBEM and 511. The operations center covers 400 miles of highway, of which three-quarters is covered with ramp meters. The center also provides data warehousing and has 15 years of data that is archived using a "homegrown" java-based data fusion tool, Intelligent Roadway Information System (IRIS)[37], which checks data quality.

The operations center's mission is to provide a unique partnership between MnDOT and the state's Department of Public Safety to quickly coordinate response to freeway crashes and incidents. Other functions are to:

- Maximize the number of vehicles a freeway corridor can handle
- Minimize congestion
- Provide traveler information
- Manage incidents and special events
- Provide aid to stranded motorists

Findings

The operations center allows a unique partnership between MnDOT and the Department of Public Safety to quickly coordinate responses to freeway crashes and incidents, maximize highway capacity, minimize congestion, provide traveler information, manage special events, and provide aid to stranded motorists.

[37] Wikipedia entry for IRIS: http://en.wikipedia.org/wiki/IRIS_(transportation_software)

Caltrans: Oakland

The MTC operates the original 511 traveler information system[38], which was started as "know before you go," and launched in 2002. It is operated through a partnership with CHP and Caltrans and provides transit (trip planner and other transit links), rideshare, bike, and other mode data. It includes travel times on prescribed routes and incident and construction alerts. The 511 service includes phone service with prompts and voice recognition, and ADA[39] -accessible shortcuts.

Use of the 511 service has grown steadily to 3.4 million hits/calls per month, of which 500,000 are calls and 2.9 million are Internet hits. It can provide comparative driving route travel times for preset routes (auto only). Survey results indicate that the public appreciates the 511 service, including travel recommendations (e.g., change mode and change trip).

Speed data are provided through loops and extensive transponders in population located on cross-bay bridges. Speed data are filled in with speed collected from Doppler radar. Thirty-five signs throughout the region display real-time travel times for comparative routes (see Figure 3.12).

Caltrans has developed proprietary software for computer-aided dispatch and uses a collection of three data sources:

- ETC through National Electrical Manufacturers Association controllers
- Speed information through detectors and solar-powered Doppler radar
- Loops at 615 locations

Caltrans has obtained a Value Pricing Pilot (VPP) program[40] grant to push real-time and static multimodal data, to a transit trip planner and to commercial media outlets for their dissemination. Through the University of California, Berkeley, Caltrans has set up a 60-mile segment as a Connected Vehicle Research initiative program test section.

Figure 3.12 ***Travel time information***

[38] 511 San Francisco Bay Area, http://www.511.org/default.asp

[39] Americans with Disabilities Act

[40] Value Pricing Pilot Program, http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/index.htm

For the I-80 ICM project, Caltrans is working with the Metropolitan Transportation Authority (MTA) to develop a coordinated project addressing the corridor's poor level of service, unreliable travel times, 20,000 vehicle-hours of delay per day, and 2,000 daily incidents. The goals of the I-80 project are to:

- Create a well-balanced system
- Maintain optimal operational viability
- Proactively avoid flow breakdown
- Detect and respond to congestion events faster
- Improve safety and security
- Manage congested flow when it does occur
- Promote transit ridership and mode shifts
- Protect local arterials from unnecessary diversion
- Manage adverse social and environmental impacts

The project includes freeway, arterial, transit, travel information, surveillance and monitoring, and commercial vehicle operations. Major freeway expansion is constrained by urban development and environmental issues. The project is expected to include adaptive ramp metering and active traffic management (see Figure 3.13) to monitor ends of queues using overhead gantries, speed advisories, and full-color matrix signs. The project also includes the potential for route detouring on arterials using route trailblazing, changeable message signs providing alternative travel times and park-and-ride space availability, and integration with East Bay SMART Corridors[41].

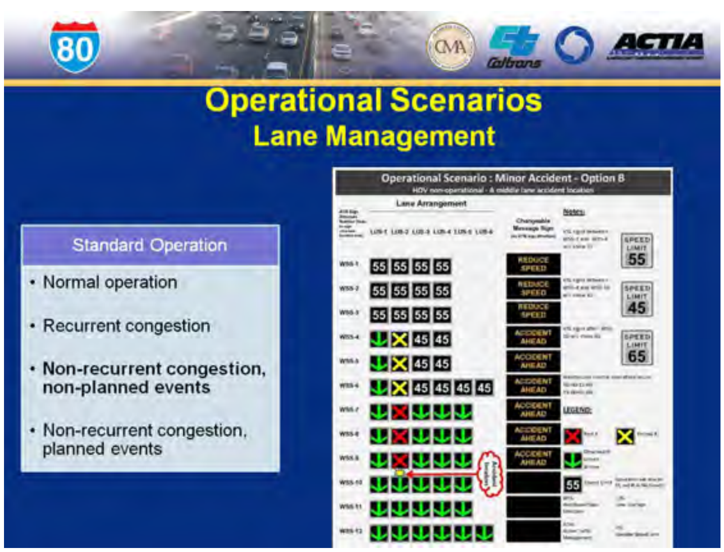

Figure 3.13 ***Nonrecurring operational scenarios***

[41] East Bay SMART Corridors, www.smartcorridors.com

The current operations center in Oakland District 4 includes CHP, Caltrans operations, and maintenance. In addition to 292 cameras, 100 DMS, and 1500 detectors, it has 25 HAR and monitors freeways and bridges. Private providers, including 29 service contractors and 25 local service patrols, respond to incidents on the local freeways. The average patrol response time to incidents is 10 minutes.

Findings

- In the Oakland area, speed data are successfully gathered using loops and by tapping into the existing toll tag resources for collection of speed and travel data. Speed data is supplemented using speed collected from Doppler radar.
- The current operations center in Oakland District 4 integrates CHP, Caltrans operations, and maintenance efforts toward real-time travel management.

Caltrans: Los Angeles

The Los Angeles Regional Transportation Management Center (LARTMC) is located in Glendale and is operated jointly by Caltrans District 7 and the CHP. It oversees roughly 500 miles of freeway with 12,000 inductive loops, CCTV cameras, 953 metered ramps, and 15 HAR. The LARTMC is a state-of-the-art essential services facility and operates 24/7.

In addition, L.A. County Metro, along with Caltrans and other agencies, developed the Regional Integration of Intelligent Transportation Systems (RIITS) in 2004. RIITS is an Internet-based regional network to exchange multimodal information in real time. It allows transportation and emergency service providers to "push and pull" data to facilitate their operations on a real-time basis. Much of the freeway system information in RIITS is pulled from the LARTMC. In turn, RIITS is the data engine that drives the regional 511 network, which was launched in the Los Angeles region in the summer of 2010. RIITS also provides a data feed to Internet service providers to enable wide dissemination of traveler information.

Findings

L.A. County Metro, along with Caltrans and other agencies, developed the RIITS, an Internet-based regional network, to exchange multimodal information in real time to drive the regional 511 network and provide data feed to Internet service providers to enable wide dissemination of traveler information.

Caltrans: San Diego

Caltrans operates an operations center with CHP in San Diego 24/7. It was initially located in Old Town, but relocated to a earthquake-proof facility. The existing 511 system[42] integrates an intermodal transportation management system, which will be available on handheld devices and will show speed flow data. The 511 system was launched in 2007. Speed data is collected using Sensys[43] puck sensors along with NAVTEQ[44] . Caltrans is migrating to radar for speed data.Data is collected and fused through PeMS.

Findings

The San Diego 511 system, in operation since 2007, integrates an intermodal transportation management system that will be available on handheld devices and will show speed flow data

WSDOT

In the early stages of developing an HOV lane system, WSDOT decided it would use the HOV project development to install single loop detection (at half-mile intervals), cameras, and changeable message signs. The loop detectors have been found to be very accurate in reporting travel speed above 3 mph. Freeways also include ramp meters. The operations centers oversee the ramp meters. Detection, cameras, and message signs are fed to seven operations centers, five of which operate 24/7.

The operations center at Dayton Avenue oversees operations in central Puget Sound. In 2013 the operations center will be moved to a seismically safe environment in an adjacent building. The facility is staffed in part by University of Washington research students.

Travel information for the entire state is pushed to the public through the WSDOT Web site[45], which also provides links to other providers and agencies. WSDOT also uses Twitter and e–alerts to provide traffic updates to subscribers. Transit agencies and local agencies provide similar e-alerts/tweets of nonrecurring congestion for construction and incidents. Travel time comparisons for various alternative routes or destinations are available on the Web site and in the field via DMS. A recent weeklong closure of I-90 for construction was well publicized in advance and resulted in substantially less congestion than predicted. The traffic impact from the project was predicted using simulation modeling that forecast drivers would use alternate routes given advance notice.

WSDOT travel information is well viewed by the public. Web page views range from 1 million on a typical day to more than 4 million daily during inclement weather or other events. Use of the state 511 calling line is less popular but still reliable. WSDOT reaches the public through YouTube, Twitter, blog posts, Flickr, and Facebook. The state has also developed popular iPhone and Android applications that provide timely traffic information.

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[42] 511—San Diego Traffic, Transit, and Commute Information, http://www.511sd.com/

[43] Sensys Networks, http://www.sensysnetworks.com/home

[44] NAVTEQ, http://www.navteq.com/

[45] Washington State DOT, http://www.wsdot.wa.gov/

Findings

WSDOT provides travel information for the entire state to the public through its Web site. It also uses social networking sites such as YouTube, Twitter, blog posts, Flickr, and Facebook.

Coordination of Construction Activity

Construction is recognized as a common and seasonal cause of congestion. To the degree construction can be planned and anticipated by the motoring public, congestion can be reduced as motorists adjust their travel patterns. Virtually all agencies the scan team visited were coordinating construction activity and including information about it on their on-line information sources or broadcasting it through a range of social media. VDOT, MSHA, DDOT, NJDOT, NJTA, and the PANYNJ have long coordinated construction information across jurisdictions to reduce congestion on parallel routes.

Findings

Coordination of construction information across jurisdictions to reduce congestion on parallel routes is a well-established well-accepted practice across agencies.

Traffic Signal Enhancements

Overview

Poorly timed or uncoordinated traffic signals are often the cause of recurring congestion. Frequent retiming and optimization of signals is costly but keeps up with changing travel patterns. Adaptive traffic signals, which use complex algorithms and multiple timing patterns to control the systems, are being used in California, most notably in Los Angeles, where traffic signal systems are coordinated between Caltrans and local agencies. The performance of these signals is easily monitored and their benefits measured.

VDOT

In northern Virginia, VDOT has jurisdiction over most roadways and maintains over 1,400 traffic signals, which are currently on a regular two-year optimization cycle to reflect changes in traffic patterns, land use, and roadway features. The computerized central signal system is capable of traffic data collection and real-time traffic control and monitoring. New timing plans are generated by software that is fed with data from roadway sensors and manual traffic counts. The output is transferred to traffic simulation models to determine impacts on traffic flow and to fine-tune timing plans. Field observations and additional adjustments are made whenever new timings are implemented.

In addition, a digital library has been created of all the Synchro files for each network. The library is used to review residents' concerns, to support signal analysis for construction projects, for inter-jurisdiction signal coordination, and for traffic impact studies of new signals.

VDOT also manages nonrecurring congestion (i.e., traffic incidents, planned special events, work zones, and weather events) and has incident timing plans available for use when needed. During incidents that detour traffic to arterials, VDOT monitors and adjusts timings in real time. Special-event timing plans were implemented for the 2009 Presidential Inauguration, election day, Independence Day fireworks in the capital, holiday shopping near malls, April 15 (tax day), and college campus and concert activities.

Findings

- VDOT manages nonrecurring congestion (i.e., traffic incidents, planned special events, work zones, and weather events) and has incident timing plans available for use when needed.
- The computerized central signal system is capable of traffic data collection and real-time traffic control and monitoring. New timing plans are generated by software, fed with data from roadway sensors and manual traffic counts.

DDOT

DDOT is developing the 10-mile, 23-intersection Georgia Avenue corridor traffic signal coordination that extends green time to facilitate 10-minute bus headways. The project maintains pedestrian crossing times.

Findings

Urban traffic signal coordination considerations include extending green time to facilitate 10 minute bus headways and maintaining pedestrian crossing times.

Caltrans: Oakland

Caltrans, with San Mateo City/County Association of Governments , Metropolitan Transportation Commission , and local cities (i.e., San Bruno, Millbrae, San Mateo, Burlingame, Belmont, San Carlos, and Redwood City), have been developing a Smart Corridor Project for Highway 101, a key highway connecting San Francisco to the South Bay communities. The project includes overall signal coordination and retiming, and upgrade of controllers, signals, fiber optics, wireless communication, signs, cameras, and vehicle detection connected to a central Traffic Management/Operations Center. The project is intended to help reroute traffic and using alternative routes during congestion. Local agencies maintain control of signals during normal operations. Signal timing plans for events are developed and coordinated with local jurisdictions.

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[46] City/County Association of Governments of San Mateo County, http://www.ccag.ca.gov/

[47] Metropolitan Transportation Commission is the Bay Area's MPO; http://mtc.ca.gov/funding/tip/

During major incidents, Caltrans takes over signal timing to help reroute traffic using trailblazing signs.

One component of the I-80 ICM project is a traffic light synchronization project. Expected benefits are enhanced safety, improved transit operation, and improved incident management. Mode shift from enhanced transit performance also requires parking management (i.e providing travelers with real-time parking information at transit stations and centers.

Findings

Caltrans is applying a strategy to help reroute traffic using alternate routes during congestion through a Smart Corridor Project that includes overall signal coordination and retiming, and upgrade of controllers and signals, fiber optics and wireless communication, new signs, cameras, and vehicle detection connected to a central traffic management/operations center.

Caltrans: Los Angeles

Caltrans has developed an adaptive traffic control system (ATCS) for five state arterial highways in the County of Los Angeles. Caltrans in District 7 operates and maintains 1300 traffic signals. The ATCS will enable arterial management through signal timing optimization based on real-time traffic conditions.Caltrans can adjust cycle length, splits and offsets to minimize stops, and other signal performance metrics (see Figure 3.14). All of the signals use model 2070 traffic controllers with existing interconnect. While coordination is needed with a number of agencies, model 2070 controllers were used to be consistent with the City of Los Angeles DOT, which shares most signals with Caltrans.

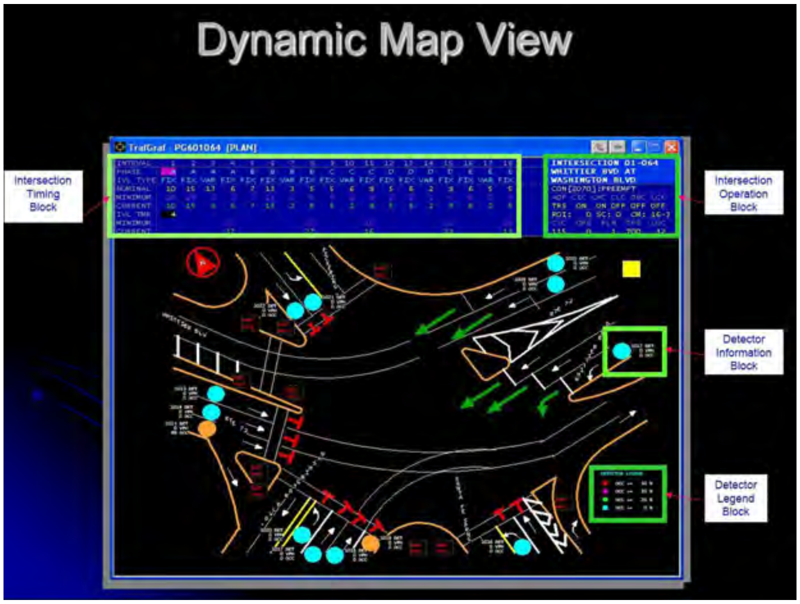

Figure 3.14 ***Remote signal operations displays***

As part of creating the ATCS, fiber optic cable and CCTV were added at 29 locations to support adaptive control. Design started in 2006. Beginning in 2007, the ATCS was constructed and implemented over 18 months, resulting in a system of five corridors, just under 60 miles, with 173 traffic signals and CCTV at 29 locations (see Table 3.1).

	Miles	Signals	CCTV
Route 1 PCH	40	97	20
Route 66 Foothill BV	5	18	2
Route 72 Whittier	6.5	26	4
Route 107 Hawthorne	5	21	2
Route 213 Western	3	11	1
Totals	59.5	173	29

Table 3.1 ***Los Angeles DOT adaptive traffic control system***

The Los Angeles DOT developed the ATCS kernel software that is at the heart of the system. The signals are managed through an operations center at Caltrans District 7 headquarters. High-speed T1 networks provide the second-by-second reporting needed for adaptive control. Detectors are installed approximately 250 feet in advance, using in-pavement loops provide to queue information.

Communications from the 2070 controller via a fiber optic modem is provided to:

- Data node
- Multiplex
- Fiber optic main trunk line
- Los Angeles Airport, Norwalk, and San Gabriel hubs
- Los Angeles Regional Traffic Management Center
- Signal Operation Center

Each server can handle:

- 512 intersections
- 99 timing plans
- 8192 system detectors
- 256 section assignments

ATCS operation has plans for:

- TOD
- Critical intersection control
- Critical link control
- Adaptive feature

The adaptive feature modifies the cycle length based on recent changes in traffic conditions without operator intervention; however, it does allow intervention. Software provides dynamic phasing view at the operations center and can show when signals are in or out of phase and why phasing is failing. It also records cycle history weekly, showing occupancy, speed and volume. It monitors effectiveness at intersections and can compare week-to-week data for establishing travel times. The capability to work with the Connected Vehicle Research initiative is built in.

Findings

The goal of Caltrans's ATCS is to enable arterial management through signal timing optimization based on real-time traffic conditions. Caltrans developed ATCS to improve signal timing along five corridors. ICaltrans can adjust cycle length, splits, and offsets to minimize stops and other signal performance metrics.

MSHA

Maryland controls over 2,500 signals, of which 1,400 are within multi-signal systems. Its goal is to retime every three years to respond to changing land use and traffic patterns.

Strategic Use of Narrow Lanes

Overview

Creating capacity by narrowing lanes has been applied successfully in temporary conditions such as emergencies like the September 11 tragedy in New York City and the collapse of the I 35 bridge in Minneapolis, where alternate roadways were adapted to add lanes. Agencies agreed that safety concerns related to design exceptions must be addressed when considering narrow lanes.

PANYNJ

After the September 11 tragedy in New York City, narrow lanes in the Holland Tunnel led to a ban on large trucks and tractor-trailers in favor of buses only in both tunnels. Transit vehicle industry revisions allowing 102-inch-wide buses is causing reconsideration of the type of vehicles that can be in the tunnels. Narrow lanes on the Staten Island bridges have resulted in difficulties responding to incidents, leading to extensive lane closures and circuitous travel. Unique tow vehicles with small turn radii are used in the tunnels to allow vehicles to be cleared from either direction.

Findings

- Before deciding to use this strategy, agencies should consider the effect of narrow lanes on large trucks, tractor-trailers and buses.

- The use of narrow lanes may result in difficulties responding to incidents, resulting in extensive lane closures and circuitous travel.

MnDOT

As part of the traffic rerouting that occurred when the St. Anthony's Fall I-35W bridge collapsed, MnDOT developed plans to fit an additional lane over the river by narrowing the three original lanes and taking the shoulder so that a fourth lane could be added in the existing road template.

Findings

The use of narrower lanes may be an effective strategy for adding more lanes to an existing roadway template.

Caltrans: Oakland

The key to the implementation of narrow lanes is vetting them to determine if any design exceptions would be required. In general, Caltrans tries to avoid 11 foot lanes; however, there are gap locations through San Rafael as well as lanes constrained by bridge width (e.g., the Benicia Bridge), where 11 foot lanes are being considered. Caltrans has developed HOV guidance protocols to assess the tradeoffs between lane widths, lane placement (i.e., inside versus outside), and shoulder width. Bus-only use of shoulders was considered but not used.

Findings

When contemplating the use of narrower lanes should designers should consider the jurisdiction's design standards to determine the applicability of the strategy and the need for design exceptions.

Contraflow

Overview

Contraflow strategies to allow a reverse lane for peak directional roadways is often used to accommodate transit only. This strategy has been used successfully for reverse-peak direction travel between New Jersey and New York to allow deadheading buses to return to New Jersey because there is not room to accommodate them in New York's Port Authority bus terminal.

MSHA

MSHA and the MdTA have evaluated the Bay Bridge (US 50) for consideration of contraflow to meet peak directional recreation travel demand as part of a construction closure of one of the bridges. They considered peak direction contraflow as part of needed construction lane closures. Typical queues during construction were anticipated to be 10 to 16 miles with delays of five hours returning from the shore (and, potentially, for evacuation). Results of the analysis showed that capacity in the reverse direction was not adequate.

Findings

MSHA and MdTA's evaluation of contraflow determined that capacity in the reverse direction was inadequate so it was not feasible.

PANYNJ

High volumes of buses use the Lincoln Tunnel daily to take passengers to New York's Port Authority Bus Terminal in mid-Manhattan. Reversible lanes are used to optimize the six available tunnel lanes. Because there is no bus storage in New York, buses must deadhead in both directions, with considerable travel time in the off-peak direction due to peak lane reversal. On I-495 between the New Jersey Toll Plaza and the Lincoln Tunnel, a reversible bus lane allows buses to get to the tunnel and the Port Authority Bus Terminal. This lane saves buses 20 to 30 minutes daily.

Findings

New York and New Jersey buses use reversible lanes by TOD to optimize the six available tunnel lanes and reduce daily travel time by 20 to 30 minutes.

Caltrans: Oakland

A bus contraflow lane was used on the Golden Gate Bridge to handle heavy directional peak flow. The lane has been removed becasue volumes have become more balanced.

Findings

The use of contraflow lanes must be continually evaluated. When they are no longer warranted, they should no longer be used.

Reversible Lanes

Reversible lanes are used where high peak directional travel exists and exclusive lanes can be "reversed," thereby maximizing flow in the peak direction. Express lanes in barrier-separated roadways that flow in to metropolitan cities in the morning and out in the afternoon are typical examples of reversible roadways. Some arterial applications are in urban areas, like Washington, D.C., where radial roadways are highly directional. However, without overhead changeable signs to delineate lanes, these facilities are being converted back to traditional two-directional roadways to reduce potential accidents.

MSHA

Two reversible lanes have been implemented, one for access to the new Redskins stadium and one to provide rural residential access and avoid roadway widening in a constrained area. In the case of the stadium, it was initially designed for 70,000 patrons but accommodates 90,000. Reversible lanes accommodate high peak demand as long as at least one opposite-direction lane is available for emergency response. Additional challenges have included accommodating high-demand pedestrian and bicycle crossings in conflict with vehicles. These challenges have been resolved.

In the case of access to the rural residential community, it is the only access to this community. A highly directional roadway is converted from one lane in each direction and a two-way left-turn lane in the off-peak to two lanes peak direction/one lane off-peak channelization during peak commute times. Lanes use double-dash striping for the center lane and overhead signs to ensure visibility. The signs display a red X or a green arrow with a flashing yellow X during transition. Operational periods are 7 to 9 a.m. and 4 to 6 p.m. . These reversible lanes have been in existence since 1999 and were evaluated in 2000, noting initially higher accident rates. MSHA did consider the higher cost of widening and accompanied the study with public outreach. The reversible-lane application is considered a success.

Findings

- Reversible lanes can accommodate high peak demand as long as at least one opposite-direction lane is available for emergency response.
- MSHA initially experienced slightly higher accident rates; however, that has subsided. The application is now considered a success.

DDOT

Because of the radial nature of D.C. roadways and high peak directionality, DDOT developed several reversible roadways, which have been in place for several years. District policy does not allow overhead signage to support reversible roadways; therefore, reversible roadways are guided by signs along the roadways. However, because of the lack of overhead signs, the lanes are confusing and 18% of accidents can be attributed to the reversible lanes.

Other drawbacks include impacts to economic development because reversible lanes cater more to through-vehicles, rather than to those accessing local businesses. Pedestrians, including many tourists unfamiliar with the local streets, may be confused when trying to maneuver across reversible roadways. Because of these challenges, some of the reversible roadways have been converted to two-way operations.

Findings

Providing proper signing is essential to the safe use of reversible lanes. This may be a challenge in urban settings.

PANYNJ

PANYNJ operates three reversible lane configurations, including a bus-only lane, at the Lincoln Tunnel to ensure achieving maximum roadway capacity to meet peak-period traffic demand.

Findings

PANYNJ successfully uses reversible lane strategies to maximize roadway capacity during the peak-hour traffic and to operate a bus-only reversible lane.

MnDOT

Three miles of I-394 are currently reversible (using gates) from 5 a.m. to 1 p.m. eastbound and 1:30 p.m. to 2 a.m. westbound. The roadway is closed from 3 to 4 a.m. daily for clearing of debris. The facility has available capacity.

Findings

MnDOT's use of reversible lanes has provided necessary capacity needs for I-394.

Caltrans: Oakland

Caldecott Tunnel is a three-bore, highly directional tunnel. The center lanes are reversible, using pop-up delineators.

Findings

The use of reversible lanes is a possible strategy for use in tunnels to provide directional peak-hour needs economically.

Caltrans: San Diego

I-15 is a barrier-separated reversible express tolled facility. It is a radial freeway that extends from downtown San Diego to residential communities north and inland. The facility is still highly directional. The reversible lanes with barrier separation have available capacity, making it an ideal candidate for managed lanes.

Findings

Caltrans's use of reversible lanes has provided necessary capacity needs for I-15.

WSDOT

WSDOT operates and maintains two reversible directional express lane corridors connecting downtown Seattle to the east on I-90 crossing Lake Washington and to the north on I-5. Both operate in the morning toward downtown and in the afternoon away from downtown. Operators close and drive the facility as part of direction reversing to ensure that the facility is clear of cars and debris. I-5 carries a higher degree of express transit. Access is provided to the reversible roadways via generally redundant ramps. Both prioritize use for HOVs and transit and operate with reliable travel times and excess capacity.

I-90 has long been designated for use by high-capacity transit and is in the process of transitioning to BRT and eventually to light rail use. Travel on I-90 has become more balanced and less peak directional, resulting in HOV demand in both peak and nonpeak directions. HOVs are now being accommodated permanently on I-90 in HOV lanes adjacent to GP lanes. To accommodate these new HOV lanes, GP lanes and shoulders were narrowed and variable speed limits are being implemented.

Findings

WSDOT operates and maintains two reversible directional express lane corridors connecting downtown Seattle to the east on I-90, resulting in reliable travel times and a better balance of demand and capacity.

Incident Response

Overview

Significant congestion is related to nonrecurring incidents, such as accidents. Quick removal of incidents has proven to be a substantial benefit in reducing congestion and related emissions. Many agencies use agency or private-service patrols to assist motorists (e.g., changing tires or providing gas to get motorists moving and remove incidents). Many agencies reported cutting service patrols in response to budget reductions.

Active traffic management allows quick clearance of vehicles involved in accidents; however, all agencies reported challenges with agency responsibilities and protocols for quickly removing vehicles involved in accidents. WSDOT provided an example joint operations policy statement (between the state troopers and the DOT) for removal of vehicles involved in accidents.

MSHA

MSHA has developed detailed monitoring and management of incident response and clearance, including partnering with researchers at the University of Maryland. In addition to other functions conducted by CHART, MSHA has developed DMS message protocols and "after action" protocols using event logic that still allows human override, including using the Web to share video so that operators can look at the same thing.

The MTA has well-developed DMS, CCTV, and service patrols along I-95. Service patrol enhancements include automated vehicle location and Capitol Wireless Information Net (CapWIN)[48]. CAPWIN-enabled laptops are installed in patrol cars to provide wireless communication. Additionally, MSHA has conducted extensive Eastern Shore evacuation analysis using CORSIM (CORridor SIMulation)[49] simulation analysis.

Findings

- Well-developed monitoring, management, and response protocols are keys to success.
- Partnerships with university researchers can be of benefit.

NJDOT/NJTA

Both NJDOT and NJTA rely on service patrols and private responders (Automobile Association of America [AAA]) to assist motorists and clear vehicles. With the advent of cellular phone technology, calls for assistance have changed from being routed to the state police and toll collectors to AAA[50] and OnStar[51] . The NJTA utilizes speed-flow INRIX data to detect incidents, augmented with CCTV. Both NJDOT and NJTA recognize the importance of clearing vehicles quickly, noting that "minutes mean miles" of backup.

On NJTA roadways, clearing accidents is coordinated through a central response center that includes the state police. "Move-it" laws are in place requiring clearance within certain time requirements. On the New Jersey Turnpike, the state police push vehicles out of the traveled way. Incident diversion routes have been developed for most of the arterial system, and NJDOT can easily deploy detour or reroute signs.

Incident management and response training promotes cross-jurisdictional support. New Jersey's federal incident response score has improved from 50 to 82.

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48 Capital Wireless Information Net, http://www.capwin.org/

49 Wikipedia entry for CORSIM, http://en.wikipedia.org/wiki/CORSIM

50 Automobile Association of America, http://www.aaa.com/

51 OnStar, http://www.onstar.com/web/portal/landing

Findings

- Incident response relies on service patrols and private responders (i.e., AAA) to assist motorists and clear vehicles. It is essential to recognize the importance of clearing vehicles quickly, as "minutes mean miles" of backup.
- Incident management and response training promotes improved cross-jurisdictional support.

PANYNJ

Within the PANYNJ crossings are 160 tunnel and bridge agents responsible for responding to emergencies. Special equipment (e.g., small-wheelbase wreckers) is used to work in tight tunnel environments and work from either side of the tunnel. George Washington Bridge safety and maintenance staff have designed fire trucks to adapt to different hydrant designs in New York and New Jersey.

Findings

Specially designed equipment should be considered where conditions dictate, such as in a tunnel environment.

MnDOT

The I-35W bridge collapse and events like the Republican National Convention have tested the ability of MnDOT and enforcement agencies to deal with incidents. MnDOT is addressing incidents proactively using its regional transportation management center (TMC). The TMC utilizes a variety of applications, such as its 511 service[42]. The FIRST includes a trained set of service patrols with extra training and special vehicles that are modified three-quarter-ton pickup trucks. They patrol eight to 11 routes and areas broken into districts from 5:30 a.m. to 8:30 p.m., Monday through Friday.

MnDOT uses the 4:1 Rule: "For every minute an incident remains, it takes an additional four minutes to recover to normal traffic flow." MnDOT responds to incidents using active traffic management applications to support the incident response efforts, focusing on responding to incidents within 10 minutes and clearing them quickly (i.e., within an hour). These active management techniques have allowed the TMC to close lanes instantly for incident management and during routine work zone closures.

MnDOT has considered expanding legislation to allow the FIRST units to work with enforcement agencies to expedite the removal of broken-down vehicles from the

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[52] Minnesota DOT 511 Traveler Information, http://www.511mn.org/

freeways. Incident management guidance has been developed since 2002. MnDOT relies on an Open Roads Policy and Hold Harmless legislation to protect towing agents, service patrols, and responders from legal action brought by vehicle owners.

During the I-35W collapse, MnDOT worked quickly and collaboratively to identify and prioritize a set of projects to accommodate increased demand due to the bridge collapse. Many of the projects were completed and travel times monitored to adjust projects.

Findings

- MnDOT incident response is enhanced through the utilization of specially trained service patrols and special vehicles that are modified three-quarter-ton pickup trucks.
- MnDOT uses active traffic management applications to support incident response efforts, with a focus on responding in less than 10 minutes and clearing them in less than an hour to reduce delays. It believes that for every minute an incident remains, it takes an additional four minutes to recover to normal traffic flow.

Caltrans: Oakland

The ICM on the ongoing I-80 construction project includes active traffic management elements to help manage flow around incidents (i.e., nonrecurring congestion), with advance queue detection, variable speeds, and advanced response and clearance. Currently, both public and private service patrols work on state highways to assist motorists and clear vehicles. Using the operations center to direct deployment, an incident can be responded to within 10 minutes.

Counties in California sponsored the installation of freeway call boxes along interstates. While the technology is antiquated and has been largely replaced by travelers with personal cell phones, the boxes are being maintained.

Findings

- Active traffic management elements to help manage flow around incidents (i.e., nonrecurring congestion) with advance queue detection, variable speeds, and advanced response and clearance during construction are effective strategies.
- Caltrans has found that using public and private service patrols on state highways to assist motorists and clear vehicles is effective in helping reduce traffic delays.

WSDOT

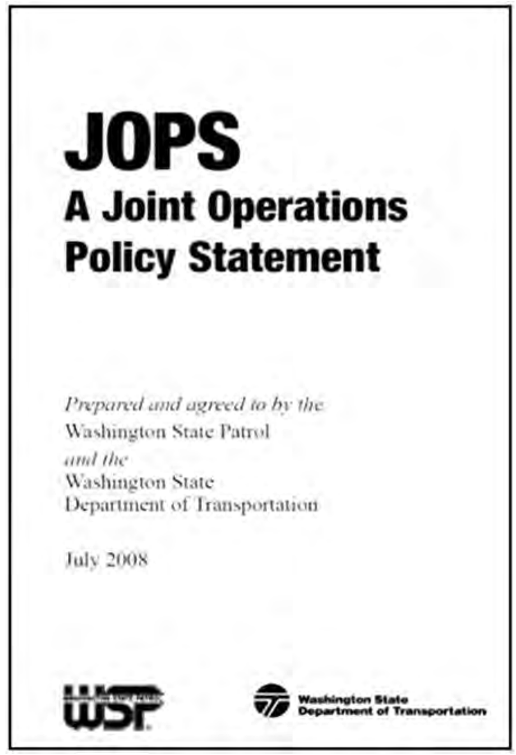
The state uses 58 service patrols statewide on 500 miles of freeway to clear incidents and help motorists clear debris. Incident clearance times have come down. Major incident tow protocols are established in a program called Blok-Buster, which mobilizes resources and clears large truck incidents within 90 minutes.

The state has developed a joint operations policy statement with law enforcement, identifying roles and responsibilities for responding to and clearing freeway incidents (see Figure 3.15). WSDOT has agreements with most county coroners to allow quick clearance of fatal accidents. Unique protocols, such as covering the vehicle, are used to expedite clearing the incident.

WSDOT also uses photo radar speed enforcement in work zones.

Findings

- WSDOT's use of public and private service patrols on state highways to assist motorists and clear vehicles is a key tool in reducing traffic delays.
- Major incident tow protocols that mobilize resources and clear large truck incidents are an effective strategy to address traffic delays.



JOPS

A Joint Operations Policy Statement

Prepared and agreed to by the
Washington State Patrol
and the
Washington State
Department of Transportation

July 2008

Washington State Department of Transportation

Figure 3.15 ***WSDOT and Washington State Patrol joint operations policy statement***

Key Findings

This section culls the preceding strategies for reducing congestion and maximizing traffic flow into general key findings. The practices are further broken down into common, best, and emerging practices.

Use of Shoulder Lanes

Key Findings

Using shoulders as travel lanes is successfully reducing congestion and maximizing traffic flow. Lanes generally benefit from being 12 feet wide.

- They are best for temporary use during peak travel periods.
- They are effective in reducing traffic bottlenecks.
- Using overhead signs and contrasting pavement are effective means of differentiating travel lanes.
- Both outside and median shoulders can be effectively used; however, median lanes offer less conflict at access locations.

Practices

Common – Use of both median and outside shoulders

Best – Use of median shoulders to mitigate conflicts at access points

Emerging – Priced dynamic shoulder lanes

Congestion Pricing/HOT Lanes

Key Findings

Congestion pricing/HOT lanes are successful in reducing congestion and maximizing traffic flow.

- HOT lanes can be effectively used with variable pricing and selling of excess capacity during peak travel periods.
- Congestion pricing rates can be adjusted dynamically, based on demand and congestion, and updated every three minutes.
- Developing an operational criterion that maintains free flow speeds in managed lanes is important. Allowing other vehicles to utilize the free space in the lane also enhances the efficiency of the entire corridor.

A variety of technical approaches can be used to support congestion pricing/HOT lanes, including:

- Direct access to park-and-ride stations
- Intermediate barrier breaks two to three miles apart to allow entrance and exit
- Open road tolling
- DMS that note costs to specific locations with travel times
- In-pavement lighting
- Zipper gates
- Pop-up delineators
- Moveable barriers
- BRT
- Notification of parking availability within the corridor to promote ridesharing/transit

Practices

Common – Use of toll facilities to manage congestion and fund infrastructure improvements

Best – Well-publicized outreach efforts effectively educating the public on use of toll facilities

Emerging – Electronic tolling is emerging as an efficient and effective way to collect revenue. Use of design-build-operate over time is increasing in use as a way to procure HOT facility improvements. Enforcement of HOT lane facility use has been effective with Raytheon mobile detection equipment, as used by MnDOT.

Traffic Smoothing

Key Findings

Traffic smoothing is successful in reducing congestion and maximizing traffic flow.

- Ramp metering is generally effective in improving the efficiency of mainline traffic and improving overall freeway performance. Operational changes in the way the meters are used, such as setting an upper limit of delay, may be warranted to ensure successful results.
- Variable speed limits can be effective in reducing stop-and-go conditions and providing smoother slowing prior to congested conditions. Gradual slowing helps reduce incidents at the end of the queue.
- Advanced warning signs are useful in warning facility users of road and traffic conditions ahead, allowing the users to take alternate routes.

Practices

Common – Most agencies have used ramp metering as a mechanism to smooth out the flow of traffic.

Best – Further study results led to some operational changes in the way ramp metering was used, such as setting a maximum upper limit of delay of four minutes at service interchanges and two minutes at system interchanges.

Emerging – Caltrans implemented SWARM, along the eastern segment of a corridor. This advanced metering strategy works by evaluating real-time traffic situations at selected and dynamic bottlenecks throughout the corridor to predict future congestion and properly set upstream metering rates, helping reduce congestion throughout the corridor.

Real-Time Travel Management/Information

Key Findings

Real-time management/information (i.e., about ongoing traffic incidents, construction work, and other traffic-related issues) is successfully reducing congestion and maximizing traffic flow.

- Co-located agencies responsible for operating a facility having common access to current speed/congestion maps, weather data, and cameras can more effectively manage incident response, construction management, congestion management, detours, closures, weather-event monitoring, and state patrol dispatch for their facilities.
- Travel information can be provided to the public through a variety of means (e.g., the DOT Web site, 511 phone system, social media, and by making information available on handheld devices).

Practices

Common – Establishing ITS and an operations center that incorporates system detection, cameras, and changeable signs to monitor and manage traffic in real time

Best –Cameras, DMS, loop detectors, and/or system data provided by the private sector are used to enable comprehensive system monitoring. Conditions are made available to the public via 511 systems, traveler information Web sites, and HAR.

Emerging – One owner reaches the public by using social networking media such as YouTube, Twitter, blog posts, Flickr, and Facebook. In 2004, one owner developed the RIITS, an Internet-based regional network to exchange multimodal information in real-time.

Coordination of Construction Activity

Virtually all agencies visited were coordinating construction activity and including information on their on-line information sources or broadcasting it through a range of social media. This practice is well established across the host agencies.

Traffic Signal Enhancements

Key Findings

Traffic signal enhancements are successfully reducing congestion and maximizing traffic flow.

- Successful traffic signal enhancement projects include arterial management through signal timing optimization based on real-time traffic conditions.
- Urban traffic signal coordination considerations should include extending green time to facilitate bus headways and maintain pedestrian crossing times.
- A successful strategy for traffic signal enhancement is to re-route traffic to alternative routes during congestion through overall signal coordination and retiming, including an incident-detection system connected to a central traffic management/operations center. Many computerized central signal systems are capable of traffic data collection and real-time traffic control and monitoring.
- New timing plans are commonly generated by software, fed with data from roadway sensors and manual traffic counts.

Practices

Common – Traffic data monitoring helps re-time traffic signals in real-time during periods of congestion.

Best – Use of a computerized central signal system for traffic data collection and real-time traffic control and monitoring is a best practice. Improved timing plans are generated by software, fed with data from roadway sensors and manual traffic counts.

Emerging – Smart Corridor Projects that include overall signal coordination and retiming and required upgrades of controllers, signals, fiber optics and wireless communication, signs, cameras, and vehicle detection, all of which are connected to a central traffic management/operations center is an emerging practice. An ATCS enables arterial management through signal timing optimization based on real-time traffic conditions.

Strategic Use of Narrow Lanes

Key Findings

Using narrow lanes to reduce congestion and maximize traffic flow is having mixed results. This strategy can be used successfully; however, it should be used with extreme caution and care.

- Consideration should be given to the effect of narrow lanes on large trucks, tractor-trailers, and buses before a decision to utilize this strategy is made.
- The use of narrower lanes should take into consideration the jurisdiction's design standards to determine the applicability of the strategy and the need for design exceptions.

Practices

Common – Successfully used in temporary conditions (e.g., emergencies like the September 11 tragedy in New York City and the collapse of the I-35W bridge in Minneapolis, where alternate roadways were adapted to add lanes). Address safety concerns related to design exceptions when considering the use of narrow lanes.

Best – Best used in temporary situations, with caution and careful consideration of safety aspects.

Emerging – Identify trade-off benefits between lane widths, lane placement (inside versus outside), and shoulder width

Contraflow Lanes

Key Findings

Using contraflow lanes to reduce congestion and maximize traffic flow is having mixed results.

- Using contraflow lanes as a strategy requires adequate capacity in the reverse direction. Using reversible lanes by TOD may optimize available lanes and reduce travel time.
- The use of contraflow lanes must be continually evaluated and discontinued when their use is no longer warranted.

Practices

Common – Typically, a reverse lane for peak directional roadways is used to accommodate transit only.

Best – Use of contraflow lanes works best when there is unbalanced flow (i.e., traffic is much heavier in one direction than the other, such as morning and evening commutes). Emerging – No emerging technologies were identified for contraflow lanes.

Reversible Lanes

Key Findings

Reversible lanes are successfully reducing congestion and maximizing traffic flow.

- Reversible lanes accommodate high peak demand as long as at least one opposite-direction lane is available for emergency response.
- Proper signage is essential to the safe use of reversible lanes. This may be a challenge in urban settings.
- Reversible lanes with barrier separation and available capacity can be a suitable location for managed lanes.
- The use of reversible lanes may initially result in slightly higher accident rates; however, the application can be a success if the higher cost of widening is considered and public outreach is done.
- The use of reversible lanes is a possible strategy in tunnels or similar restrictive locations to provide directional peak hour needs economically.

Practices

Common – Reversible lanes are used where high-peak directional travel exists and exclusive lanes can be reversed to maximize the flow of traffic.

Best – Overhead signs or other physical features are used to help delineate reversible lanes.

Emerging – No emerging technologies were identified for reversible lanes.

Incident Response

Key Findings

Incident response capabilities are successfully reducing congestion and maximizing traffic flow.

- Owners use service patrols and private responders (e.g., AAA) to assist motorists and clear vehicles.
- Owners recognize the importance of clearing vehicles, noting "minutes mean miles" of backup. Active use of traffic management applications to support the incident response efforts is critical, with a focus on responding to and clearing incidents quickly and aggressively.
- Small-wheelbase wreckers are used to work in tight tunnel environments and can work from either side of the tunnel.
- The FIRST includes a trained set of service patrols with extra training and special vehicles that are modified three-quarter-ton pickup trucks.
- Major-incident tow protocols are established in a program called Blok-Buster to mobilize resources and clear large truck incidents within 90 minutes.

Practices

Common – Integrated traffic incident management efforts allows for the quick clearance of vehicles involved in accidents; however, all agencies reported that the challenges lie within the agreements among agencies for responsibilities and protocols to remove those vehicles quickly.

Best – Some owners have set goals and target times for clearing vehicle-related incidents. For example, MnDOT quickly responds to incidents using its traffic incident management applications to support the incident response efforts, with a focus on responding to incidents in less than 10 minutes and clearing them in less than an hour. The active traffic management signing and controls that are in place enhance these efforts.

Emerging – Major-incident tow protocols are used to mobilize resources and clear large truck incidents within 90 minutes. One example is WSDOT's Blok-Buster program.

Lessons Learned

The team asked each of the host agencies to share lessons learned from application of the strategies.

Virginia DOT

One of the notable lessons learned from VDOT was the use of variable speed signs along the Woodrow Wilson Bridge. VDOT believed that these signs were ineffective in influencing driver behavior as it was deployed. Part of the issue was they were not enforced at the level they had hoped. This has led to a less than favorable review of this particular application. The lesson here is that a system needs to be well designed, located in the proper application, and well supported with the data and resources necessary to operate it effectively.

VDOT staff attributes much of its success to the commitment of its leadership. Maintenance and upkeep of software and hardware are essential in an operations center. The VDOT operations center has benefitted from locating the supervisors' coordination console within the center. The staff noted that close collaboration among operational,design staff and regional planning is essential. VDOT has found that travel times and speeds have proven to be good performance measures. It has developed an in-depth concept of operations plan for its operations center and protocols to guide responses and coordination. VDOT is looking to other agencies (e.g., Caltrans) to identify methods for quantifying the benefits of ICM strategies.

Maryland State Highway Administration

Like VDOT, MSHA noted that variable speed limit signs were not effective where they were used (i.e., in the Washington D.C. area and on several other high-volume roadways).

The agency has benefitted substantially by the close coordination with research organizations and is learning from its after-action analysis of incidents and events. Performance measures MSHA uses to assess success include detailed incident response tracking, including number and clearance times. MSHA staff noted that analysis of ITS solutions found them to have generally favorable benefit-to-cost ratios. However, this has not translated into the project prioritization process for funding at the MPO when compared to large infrastructure projects.

MSHA indicated that detailed data being stored and analyzed for incident response tracking have lead to a number of helpful performance measures, such as number of incidents responded to, response times, and clearance times.

Northern New Jersey

Overall, there is high satisfaction with public outreach of incidents and traveler information; however, it is unmeasured or not quantified. The agencies noted that they are focused on positive outcomes, rather than just positive output. They are increasing their use of VMS signs.

Agencies note the importance of leadership and commitment at the top to avoid turf wars. Their staff worked to maintain the most effective incident management response across agencies regardless of political boundaries.

The agencies are developing predictions of incident results at five, 10, and 15 minutes so that they can manage outcomes through response, traffic control, and routing.

Public education was recognized as key to their success. The New Jersey agencies recognize the benefits of outreach and providing traveler information to the public. They also noted that while the benefits are difficult to measure, their policy maintains that educating the public is important.

Minnesota DOT

MnDOT did a detailed analysis of its ramp-metering program in the Twin Cities after the legislature instructed the agency to turn off the meters. Before and after results showed a significant decline in freeway performance without the ramp meters. At the same time, MnDOT did find some areas for improvement in their metering approach. One such change was a new policy that limited the delays on ramps to no more than four minutes. The DOT's guarantee of waits at the ramps of no longer than four minutes helped it gain the public's acceptance of ramp metering. MnDOT believes that performance measures have helped improve the ramp-metering program.

MnDOT has an extensive program to ensure that its loop detectors are working properly. As a result, it has one of the highest rates of detector reliability in the country. MnDOT maintains a perspective of "we can do a lot with a little, but can't do everything with nothing."

It is an advocate for keeping software and hardware current. It has not needed to utilize private data at this point.

Caltrans

Oakland

The results from the application of the strategies discussed in this report are influenced by local road user behavior and may vary, even within a state. For example, Caltrans's experience implementing HOV lanes varies across the state. In northern California, HOV lanes have been implemented as time-of-day solutions, with facilities open to all traffic during nonpeak times and with minimal barrier separation between GP lanes and HOV facilities. Southern California typically experiences long, recurrent congestion that has resulted in HOV lanes being restricted 24/7.

To encourage the use of LEVs, HOV lanes have been opened to registered LEVs. HOV lane vehicle occupancy generally is set at 2+, except on the three northern Bay bridges, which are set at 3+, with the goal of achieving a flow rate of 800 vehicles per hour for a travel time advantage. California concentrates on providing additional enforcement for HOV routes with violation rates higher than 10%.

The public has accepted HOV lanes unless the lanes are being overtly violated or are underused. Public complaints and underuse led two southern bay crossings to reduce their HOV occupancy from 3+ to 2+ in 1992.

Applications need to be monitored and modified as traffic conditions change over time. The contraflow lanes on the Golden Gate Bridge operated with an exclusive reverse bus lane for many years. As flow on the bridge became more balanced, maintaining the bus lane caused congestion in the off-peak direction; the lane was removed in 1986.

Another example is Caltrans's experience on the Contra Costa I-580, which was opened with HOV lanes after the 1989 earthquake closed I-280. In 2000, the lanes were converted back to GP use because they were generally empty. Alameda I-580 in the early 1970s was identified as needing expansion. Public opinion resisted freeway expansion in favor of HOV shoulder lanes. After the lanes were built, they were eventually converted to GP lanes. Current legislation prohibits HOV lanes in unincorporated (i.e., rural) areas. New legislation is being proposed that will allow conversion of HOV lanes to either HOT or express toll lanes. New legislation would also allow express toll lanes to be constructed using design-build techniques.

Ramp metering has had very positive results in many different regions of California. Caltrans's theory is, "You wouldn't have an intersection without a signal, so why have an interchange without a ramp meter?"

HOV lanes have been deployed successfully in both northern and southern California. Design and operation differences are mostly related to the length of congested conditions in the corridor. Ramp metering is considered successful throughout the state. Cameras offer benefits in enhancing detection and real-time management of traffic incidents.

Los Angeles

Adaptive traffic-signal control is applied uniquely in the region and has proven beneficial in daily operation. District 7 has successfully implemented a variable lane management effort at a busy interchange. To help distinguish the changing lane configurations at different times of the day, the district uses in-pavement lighting called Smartstud. This lighting has increased the performance of the interchange and allowed for maintenance without cutting the pavement.

Caltrans District 7 notes the importance of maintaining hardware and software.

San Diego

Both Caltrans and SANDAG staff believe that their strong partnership has been critical to their success in implementing projects like the I-15 managed lanes. In addition, the staff acknowledges the importance of strong, committed, and innovative leadership and partnership

The two agencies also referred to the consistent vision provided by the mobility pyramid (see Figure 2.1), but noted the importance of understanding each community's uniqueness. Success in one location does not automatically mean success somewhere else.

SANDAG sees sustainability as a priority for the future. It is moving forward with the long-range regional transportation plan that will be one of the first to address new sustainability criteria. SANDAG is ahead of some communities as it prepares for Connected Vehicle Research initiative applications and evaluations. San Diego notes the importance of strong partnership between agency owners. Sustainability is a focus for the future in San Diego.

Washington State DOT

WSDOT has benefitted from strong leadership, a commitment to maintaining ITS elements, and a durable implementation plan that installed ITS elements while HOV lanes were being developed. WSDOT also has benefited from working to create strong partnerships with its local planning agencies. The agency adheres to an "early and often" public outreach policy to maintain a well-informed and supportive public base. WSDOT has developed an incident response joint operations policy statement[t53] (see Figure 3.15) that can serve as a good model for other agencies. The agency's staff noted its success in its incident response capabilities due to this statement, which was developed jointly by WSDOT and the Washington State Patrol.

[53] JOPS: A Joint Operations Policy Statement, http://www.wsdot.wa.gov/Operations/IncidentResponse/partnerships.htm

Performance Measures

As part of open government, quantifying benefits is becoming a higher priority. Specifically, performance measures that link to goals and objectives are highly desirable in justifying strategies. The host agencies discussed their performance measures, how data are collected, and how they are being used.

New Jersey DOT, New Jersey Turnpike Authority, and Port Authority of New York and New Jersey

These agencies are utilizing benefit-cost ratios for justification of ITS-type solutions. They acknowledge that reductions in secondary incidents and fatalities are a notable benefit; this is a national trend.

The agencies organize their performance measures as follows:

- **Safety** – Reduce the number of crashes, injuries, and fatalities.
- **Reliability** – Minimize the variability in travel times from one trip to the next for the same segment of road.
- **Capacity/throughput** – Increase the number of vehicles and passenger trips per unit of time.
- **Mobility** – Reduce delays and improve reliability by such measures as spreading peak demand, and increase transit ridership through improved customer information and knowledge of choices.
- **Incident response times** – Reduce congestion and improve safety by improving incident identification, response, and clearance times.
- **Energy and environment** – Save fuel and reduce greenhouse gas emissions.
- **Customer satisfaction** – Survey drivers, transit riders, and commercial vehicle operators.
- **Financial performance** – Reduce operation and maintenance expense and lifecycle costs through open systems and scalable solutions.

The key performance metric for NJDOT, NJTA, and PANYNJ is travel time reliability. NJDOT and the NJTA use commercial data (INRIX) and conduct simulations for estimating operations.

Minnesota DOT

MnDOT staff recognizes the importance of measuring and monitoring performance. Similar to other agencies, the metrics MnDOT uses include:

- Travel time
- Reliability

- Incident response and clearance
- Reduced crashes
- Cost benefits

As part of the UPA project, comparative travel times by route and mode are being provided and parking availability will be included. Caltrans

Oakland

The I-80 project, which includes ICM, provides an opportunity for Caltrans to advance performance measures. The following were measured as part of the project:

- Average delay savings/day (vehicle hours)
- Average vehicle occupancy rate
- Average value of travel time/person
- Number of peak period incident days/year
- Expected savings (delay reduction, accident costs)

A freeway performance monitoring partnership with MTC and congestion management agencies has changed the way projects are evaluated by emphasizing recurrent congestion created by bottlenecks and nonrecurrent congestion created by incidents. A microsimulation model is being used to evaluate recurring congestion and ramp metering.

Los Angeles

Performance measure examples include:

- Travel time
- Fuel consumption
- Operations and volume to capacity
- Air quality

Additionally, impact on air quality and effects on low-income populations are key criteria in Los Angeles.

San Diego

- Similar to other agencies, Caltrans uses the following metrics: Travel time
- Incidents
- Level of service

- Sustainability
- Energy use
- Air quality
- Greenhouse gas reduction

It is also looking at sustainability, energy use, air quality, and greenhouse gas reductions as criteria for comparing solutions.

Washington State DOT

WSDOT has established *The Gray Notebook* in response to the state's Government Management Accountability and Performance requirements. *The Gray Notebook* includes performance measures such as:

- Incident clearance times
- Sustainability
- Travel time reduction
- Hours of delay
- Crash severity reduction
- On-time ferry service

Metrics that are related to sustainability and are being assessed include the portion of the WSDOT fleet that is electric, fuel economy, and reduction in carbon intensity.

Planning

Virginia DOT

VDOT has developed an ITS decision support tool that gives planners and project developers a tool to help identify which ITS solutions are best to incorporate into other capital projects. The tool, which is located on the ITS architecture Website, is a high-level education tool for other state technical staff.

VDOT has also developed a prioritization system for ITS/operations projects that should help in the project selection and planning process. Program evaluations are beginning to include specific performance measurements that will provide data on the real benefits of ongoing efforts. VDOT has begun to incorporate the systems engineering process into the project development stage and into design and implementation.

Maryland State Highway Administration

MSHA and University of Maryland staff have developed an online course[54] on unconventional arterial intersection design as a strategy for avoiding expanding roadways to meet peak-period intersection demands.

Washington, D.C., DOT

Project development in Washington, D.C., is achieved by coordination and engagement with the public and other constituents and customers. The District relies on social media tools, including blogs, to communicate with residents.

DDOT has also implemented a bike-borrowing program to place bikes in strategic locations. The bike style is unique, and they are difficult to steal. The program has 1,200 members, and the bikes are used 60 to 140 times each day.

Minnesota DOT

MnDOT has developed the Congestion Management and Safety Plan[55] as a way of identifying and prioritizing projects to improve traffic flow. These projects tend to provide high benefit for low cost. The focus of this planning is to look at the root causes of congestion (e.g., entering demand, merge areas, and weaving). The underlying object of this effort is to use "every inch" of the pavement in the most effective manner. Projects are evaluated over established districts to ensure that they are evaluated as part of a system.

Caltrans

Oakland

Numerous agencies are involved in planning for the San Francisco metropolitan area. Central to these are the MTC (the MPO) and Caltrans.

Los Angeles

Similar to other Caltrans districts, Districts 7 and 12 work closely with planning and transit agencies to develop and implement projects. Planning and goals reflect the mobility pyramid. Their ITS planning includes an integrated vision with many agencies and focuses on the root causes of congestion. Coordinated planning for nonrecurring events has included use of freeway data by Caltrans District 7 since

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[54] An Applied Technology and Traffic Analysis Program, http://attap.umd.edu/bbs/zboard.php?id=Tools

[55] MnDOT Congestion Management and Safety Plan, http://www.dot.state.mn.us/metro/projects/cmsp/

the 1986 Olympics. Earthquakes and wildfires have tested Caltrans's coordination and planning with other Los Angeles transportation planning agencies.

San Diego

A close partnership between SANDAG and Caltrans helps ensure that planning is well coordinated. SANDAG is in the process of updating its regional transportation plan for the region going out 40 years. This innovative plan will address energy use, sustainability, climate change, and greenhouse gas reduction. It will also implement smart growth strategies linking transportation infrastructure and land use. Planning coordination also includes meeting statewide priorities.

In the future SANDAG and Caltrans will develop a unified transportation pass for tolls, parking, and transit that will build on FasTrak[56], the regional tolling transponder. They anticipate soon being able to push traveler information to customer's personal devices and are testing vehicle occupancy and detection. Results are expected soon.

Washington State DOT

In 1995, WSDOT developed a unique funding mechanism (i.e., Q-funds) for implementing operations, safety and efficiency, and minor enhancements to the transportation system. The biennium (i.e., two-year) budget has increased from $20 million in 1995/1996 to more than $60 million at the time of the scan. Another source of money is low-cost enhancement funds, which are discretionary and used for quick response to customer complaints, traveler information enhancements, and strategic enhancements of management systems. Biennium funding has ranged from $5 million to almost $10 million.

WSDOT has worked with the Puget Sound Regional Council, the MPO, and other regional providers to develop a 2040 regional transportation plan. Areas identified for future consideration include:

- Health implications
- Bike and walk trips affected by local infrastructure investments (e.g., sidewalks and bike lanes)
- Management/operational strategies
- Demand management programs

Similar to Caltrans, the Puget Sound Regional Council has developed a pyramid

[56] FasTrak is a registered trademark of the Transportation Corridor Agencies (TCA); https://www.thetollroads.com/fastrak/learnmore.php

prioritizing strategic capacity. This message is consistent with the WSDOT logo for Moving Washington (see Figure 2.2).

Summary

VDOT has developed an ITS decision support tool that gives planners and project developers a tool to help identify which ITS solutions are best to incorporate into other capital projects. The tool, which is located on the ITS architecture Website, should help integrate ITS into mainstream projects.

MSHA and University of Maryland staff have developed an online course on unconventional arterial intersection design as part of evaluating alternative designs as a strategy for avoiding expanding roadways to meet peak-period intersection demands.

Project development in Washington, D.C., is achieved by coordination and engagement with the public and other constituents and customers. The District relies on social media tools, including blogs, to communicate with residents.

MnDOT has developed the Congestion Management and Safety Plan as a way of identifying and prioritizing projects to improve traffic flow. These projects tend to provide high benefit for low cost.

The Caltrans ITS planning includes an integrated vision with many agencies and focuses on the root causes of congestion. Through a close partnership between SANDAG and Caltrans, planning is well coordinated. SANDAG is in the process of updating its regional transportation plan for the region going out 40 years.

WSDOT has worked with the Puget Sound Regional Council, the MPO, and other regional providers to develop a 2040 regional transportation plan. Areas identified for future consideration include:

- Health implications
- Bike and walk trips affected by local infrastructure investments (e.g., sidewalks and bike lanes)
- Management/operational strategies
- Demand management programs

Challenges

This scan provides an opportunity to identify challenges facing agencies. Challenges that are common to many agencies should be of particular interest. In particular, the team noted that where one agency may have identified an issue, at the same time another agency has developed solutions.

One of the challenges several agencies raised is the proactive maintenance of technology, either keeping software versions updated or maintaining hardware. Since the lifecycle of software technology is relatively short compared to that of hardware, software needs to be monitored and maintained. To address these problems, VDOT has hired in-house software developers and San Diego has created a proactive plan for program development.

Several agencies have developed custom programs to establish operational protocols for changeable signs. While these programs might be available as freeware, it is not broadly known what software is available. Maintaining roadways often is a higher priority than maintaining technology.

Technology solutions like ITS infrastructure do not attract as much attention as large infrastructure improvements, even with much higher returns on investment. Without this publicity, ITS and operations solutions may not fare well when competing for funding with infrastructure. Many agencies are establishing dedicated funding categories to expand detection, changeable signs, and cameras. Performance measures such as safety improvements and return on investment using delay information have been used to support investments in ITS.

Another challenge with technology is the rate at which it is being developed versus the rate at which it is being implemented. This creates a difficult decision when moving to different software versions or updating the current software, with the potential for newer versions making current programs obsolete.

Detection of vehicle occupancy in HOT/express facilities is an issue. Carpool restrictions may vary between two to three people. Currently the only effective way of determining HOV occupancy is through police enforcement, which can be a costly and inefficient method. Many agencies indicated performance guarantees for HOT and HOV lanes; however, increasing occupancy requirements (i.e., from two to three) is challenging, even if policy exists. Similarly, metering freeway-to-freeway ramps and HOVs is not universally implemented.

The lack of uniformity and compatibility among transponders is an issue that technology will eventually address. With diverse products and manufacturers, it is becoming increasingly important to make sure that all hardware is compatible with existing infrastructure and software. Uniformity in purchasing transportation services or access (e.g., HOT lanes, bridge tolls, transit, and parking) through one account is desirable for consumers and may have benefits for creating transportation data, including real-time decision-making.

Finally, new external influences are changing the way ITS, active traffic management, and advanced traffic signal detection are assessed and may impact decision making on investments. The measurement and regulation of environmental criteria, including sustainability, environmental justice (i.e., where a service is provided for a fee), and air quality are evolving.

CHAPTER 4

Team Recommendations

Based on the knowledge gained from host discussions and presentations, the team identified recommendations and outlined proposed implementation ideas.

Common Practices

Many of the agencies visited on the scan tour employed many similar methods and practices for improving traffic flow and relieving congestion. These common practices include maintaining and supporting ITS hardware and software systems, including loop and other detection, and DMS and CCTV that allow agencies to broadcast Web-based traveler information (e.g., 511 systems) and respond to traffic incidents.

Many agencies are managing and coordinating work zones on freeways and reporting information through Web applications. Benefits from this common practice include maximizing the vehicle capacity of a corridor, minimizing congestion, providing travel information, managing incidents and special events, and providing aid to stranded motorists.

Reversible lanes within established barrier-separated rights-of-way (e.g., express lanes) are a fairly common practice where very high directional volumes are present. The option to change directionality during certain hours allows agencies to increase the roadway capacity in one direction when the opposing direction's traffic demand is low. Lanes typically use a variety of striping with overhead signs and gates to ensure safe and appropriate use of the reversible lanes.

Ramp meters are not used universally and have been controversial in some communities. However, where they have been used for a long time, ramp meters have been proven very effective at maintaining freeway speeds and reducing travel times.

Quick response to incidents is a high priority for many agencies, particularly where huge bottlenecks occur with vehicle breakdowns in areas where shoulders do not exist or are limited. Many agencies have been using public or private service patrols/towing agents toclear vehicles and roadway debris, as well as respond to other nonemergency requests. Quick removal of breakdowns and accidents can eliminate or reduce congestion from nonrecurring events.

Use of shoulders for peak-period travel lanes has been a practice for some agencies for many years, specifically for use by professional transit drivers. cifically for use by professional transit drivers.

Best Practices

The best practices to mitigate traffic flow are ones that are carefully planned and implemented with a vision of the future and do not solely focus on current issues. Congestion pricing and managed lane systems are often implemented as HOT lane systems, with the excess capacity of existing HOV lanes being used by SOV drivers who pay a toll to use the lanes. The demand is regulated through dynamic pricing that fluctuates in accordance with the congestion and space available for toll payers. These types of HOT lanes are becoming an industry best practice. They also provide incentives for use by HOVs and transit.

Advanced traveler information using ITS elements such as loop detection, DMS, CCTV, and radar is being used effectively to provide detailed real-time traveler information through a variety of media, including Web-based applications and handheld devices. Advanced traveler information is being combined with information on construction activity and work zones.

Incident response has incorporated technology such as automated vehicle location devices to aid dispatch and reduce response times. Many agencies use service patrols (public or private) to quickly clear incidents. Many states are putting in place “quick clearance” regulations that allow quicker incident removal and liability protection for public and private towing.

Maintaining signal progression through creation of multiple signal timing plans to respond to a variety of demand patterns is becoming more commonplace. Maintenance signal timing is becoming a higher priority to agencies.

Greater use of shoulder driving, for certain periods of time and/or for professional drivers, can effectively address short-duration bottlenecks. Supplemental signs, pavement markings, and monitoring systems can aid the safe use of these facilities.

While many of these strategies do not have high capital costs, they provide high yield for maximizing traffic flow. To justify these ITS-type solutions, agencies must look further than cost-benefit ratios. Performance measures are an effective practice to analyze the methods being used. Several important measures include safety, reliability, capacity/throughput, mobility, incident response time, energy usage, environmental impact, customer satisfaction, and financial performance. All of these criteria should be considered when addressing traffic flow.

Emerging Practices

As transportation technology matures, it can be applied in new and different ways to maximize traffic flow.

Dissemination of traveler information is advancing to provide real-time traffic information that is easily accessible via the Web and handheld devices, including the availability of transit and parking at transit stations. In this way, travel information can influence travel choices, including routes and modes. Traveler information is being expanded in places like the San Francisco Bay area to provide the best travel routes customized to meet customer needs. Documenting the benefits or results from disseminating traveler information can eventually help in better predicting demand because of recurring and nonrecurring events.

Photo radar applied in work zones is also helping to enforce work zone speeds.

An emerging practice is using automated traffic management (ATM) to control speed and flow on each lane of the system using overhead lane control signs to close lanes for construction, incidents, or other events and to provide variable speed limits appropriate to the event. Although ATM is more popular in Europe, several jurisdictions in the U.S. have plans to implement these systems.

Regional planning is becoming a stronger partner with traffic operations. Through a variety of sources, including commercial providers, travel data is becoming more sophisticated and available in finite increments (e.g., every 30 seconds). Fusing data from vehicles, detection, and other sources to serve a multitude of uses is emerging. It is used to predict the congestion effects of incidents or events over time and manage traffic first through active traffic management and eventually through corridor management using adaptive (i.e., change-on-the-fly) traffic signal control and ramp metering.

Another emerging practice is time-of-day use of shoulders by buses. When augmented with DMS and detection, this practice may open shoulders to other professional drivers. The Connected Vehicle Research initiative may make high-capacity use of the lanes possible with guided vehicles and shorter distance between vehicles.

Other new technologies are advancing to support enforcement, such as passenger counting technologies for HOVs and uniformity and consistency of transponders. Pavement lighting using efficient LED technology can further enhance visibility and safety. Agencies are working with academic institutions in creating new applications for data fusion, including incident response modeling.

Additionally, policies are evolving for applying strategies as agencies come to grips with budget constraints. These policies may establish performance criteria for congestion pricing or ramp metering policy. allowing ramp metering on system interchanges, metering HOV bypass lanes, and eliminating preferential treatment for LEVs.

Recommendations

Recommendations for advancing the best practices for maximizing traffic flow are:

- **Ramp metering**, most notably on “closed” systems like I-210 in Los Angeles, appears to have a high return on investment for maximizing flow in concert with operational algorithms (e.g., SWARM) and performance guarantees (e.g., MnDOT’s 4- and 2-minute meter waits for service and system ramps respectively).
- **Adaptive traffic control systems** have substantial potential for maximizing traffic flow, including working with parallel freeway systems and with newer technologies as they mature (e.g., Connected Vehicle Research initiative). Make available example cooperative agreements/protocols between jurisdictions for operating traffic signals, including the type and number of signal plans developed.
- **Incident response using service patrols that can be tracked and efficiently deployed** is very effective at eliminating nonrecurring congestion. Additional research into optimal levels of service, including establishing benefit-cost, would be useful for agencies to support budget priorities.
- **Make accessible prototypical agreements** for ATM operations concepts, IT/traffic operations center boundary agreements, and joint operational protocols for incident response.
- **Communicate the availability of publicly developed software** for ramp metering, incident resolution and management, and data fusion (e.g., IRIS in Minneapolis and RITIS in Maryland).
- **Take advantage of evolving networking tools** to share information, ideas, and examples among practitioners.
- **Use outreach and branding** (similar to Caltrans and WSDOT) to clarify the relationship and role of efficient operations with managing demand and making the best use of existing capacity.
- **Further develop—and possibly standardize—performance measurement through partnerships** among operations/maintenance,planning and research organizations to improve the understanding of benefits, specifically in comparison with large infrastructure expansion. More research on performance measures could be undertaken.
- **Provide an avenue for the comparison of agency thresholds** for implementing such items as when HOV bypass is used at ramp meters, when HOV occupancies are increased, ramp metering rates are changed, and when meters might be considered on freeway-to-freeway ramps.
- **Emphasize the importance of customer focus on advanced traveler information** as they become able to provide real-time traffic and travel choices

and feedback on those choices. While not specifically measured, 511 service that uses Web-based technologies to push travel information has been overwhelmingly useful in reducing congestion during incidents, events, and construction. Measures of congestion reduction have been anecdotal, and more research into results would be useful.

- While technology has advanced and can utilize Web-based technologies to push travel information, **an open and trusting relationship with private news media** is also essential to ensure that the broadest audience is reached.
- **Develop a core list of elements for smaller agencies to deploy to maximize traffic flow**, including detection, monitoring, and messaging; operations center; operational protocols for incident detection and removal; and work zone coordination.

The public sees the transportation system as a single service to be provided, and it is important to move toward meeting that expectation. **Collaboration, coordination, and cooperation between jurisdictions and services** (e.g., highway, transit, enforcement, and planning) are essential for increasing public trust and satisfaction, improving decision making, and, ultimately, increasing efficiency.

CHAPTER 5

Implementation Plan

The scan team identified several potential dissemination avenues for the results of this scan. These avenues are listed below:.

- Publishing articles in magazines and professional journals, including TR News and The Research Digest
- Providing AASHTO Web site content
- Making presentations at appropriate AASHTO committee meetings
- Making presentations at regional meeting for state DOTs
- Using the FHWA Web site and other information exchange opportunities
- Conducting webinars
- Making presentations to the TRB Committee and at appropriate association meetings
- Sharing results using contemporary social media
- Incorporating best practice information into reauthorization initiatives
- Providing a knowledge transfer session (webinar) to the host scan agencies
- Sharing best practices with appropriate SHRP 2 researchers and LTAPs
- Sharing innovations through AASHTO's TIG
- Creating and distributing a CD of the best practice findings
- Establishing a peer-to-peer network

The following discussion gives further details of these dissemination avenues.

A traditional means for sharing information in the transportation industry is through the monthly periodicals that are widely read by professionals Examples of such publications are *Public Roads*[57], *Better Roads*[58], and *Governing*[59]. These magazines are widely circulated to agencies and individuals who could benefit from the findings of this scan.

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[57] *Public Roads*, http://www.fhwa.dot.gov/publications/publicroads/index.cfm

[58] *Better Roads*, http://www.betterroads.com/

[59] *Governing*, http://www.governing.com/

AASHTO's web site is a popular and effective tool for distributing information to state DOTs and other public and private sector groups and individuals. Posting one or more summaries of the scan to the AASHTO Web site will help share this information with a wide audience.

TR News is published by the TRB six times a year. Each issue contains relevant information about current and emerging subjects in the transportation industry. The article format in *TR News* is conducive to a comprehensive look at the findings of this scan.

The TRB publishes the *Research Digest* and offers a more succinct format for sharing the scan's findings. Typically, an issue of the *Research Digest* is subject specific and would lend itself well to these Best Practices

Many of AASHTO's standing committees and subcommittees are established to cover the precise topic areas of this scan. The members of these bodies are typically in positions within their own organizations that would allow them to implement the findings of the scan, resulting in tremendous payoffs through reduced congestion and more efficient traffic flow. Further, they represent the primary sponsors of this scan. As such, members of these bodies should be exposed to the findings and best practices identified by the team.

State DOTs meet at least annually in a regional format to share information and address issues that reflect some of their unique geographic needs. The scan team believes that these regional meetings offer valuable opportunities to share information. Among these regular meeting are:

- Northeast Association of State Transportation Officials (NASTO)[60]
- Southeast Association of State Highway and Transportation Officials (SASHTO)[61]
- Mississippi Valley Conference of State Highway and Transportation Departments[62]
- Western Association of State Highway and Transportation Officials (WASHTO)[63]

Another venue for effectively disseminating the findings of this scan is through the FHWA. The FHWA works hard to share information with the transportation industry through its Web site[64] and other avenues. As one of the agency sponsors of the scan, it is logical that the FHWA will assist with the dissemination of best practices in maximizing traffic flow on existing highway facilities.

[60] Northeast of State Transportation Officials, http://nasto.org/

[61] Southeast Association of State Highway and Transportation Officials, http://www.sashto.org/

[62] Mississippi Valley Conference of State Highway and Transportation Departments, http://www.mississippivalleyconference.com/Home.html

[63] Western Association of State Highway and Transportation Officials, http://www.washto.org/

[64] Federal Highway Administration, http://www.fhwa.dot.gov/

Webinars have become a very popular medium to communicate critical information to a large audience at one time. The scan team believes that conducting webinars will assist in getting this information out to a large audience who may not be able to attend the other meetings and venues listed in this section. It is envisioned that the webinars may be specific to one focus area rather than trying to address all of the best practices described in this report.

Numerous opportunities exist to present the findings and best practices of this scan to the many committee meetings and sessions sponsored by the TRB. These opportunities may occur either at the annual meeting, held in January in Washington, D.C., or at the summer meetings of the various TRB entities.

The team recognizes that potential users of the best practices identified during this scan will be more readily reached through contemporary social media, such as YouTube, Facebook, Twitter, or a blog. The team will endeavor to move contents from this report and the review of these agencies to members of the industry through a sampling of these tools.

The current transportation authorizing legislation (SAFETEA-LU[65]) expired on September 30, 2009. At this time, efforts are continuing to create and pass a replacement bill in Congress. This opportunity typically only comes once every five or six years, so the team felt it would be appropriate to bring information relating to these best practices to those involved. This will be done through a variety of agency and association initiatives.

Key professional associations in the transportation industry will want information from this scan to be shared with their at-large members. National meetings of such organizations as the Institute of Transportation Engineers[66], American Society of Highway Engineers[67], and the American Society of Civil Engineers[68], to name a few, represent rich venues for doing this.

The agencies visited by the scan team were generous in presenting information and practices. The team observed some common best practices among them, while others were unique to single states. The team believes that a webinar for these agencies would allow the contents of this report to be shared and provide a return for the time they spent sharing with the team.

The TRB has a major research initiative underway that is focused on innovation in transportation. Research efforts are divided into four areas: safety, renewal, reliability, and capacity. The team will share the results of this scan with

[65] Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, http://www.fhwa.dot.gov/safetealu/

[66] Institute of Transportation Engineers, http://www.ite.org/

[67] American Society of Highway Engineers, http://www.highwayengineers.org/

[68] American Society of Civil Engineers, http://www.asce.org/

appropriate leaders of the SHRP 2 initiative to ensure that the scan findings are reflected in their efforts.

The Local Transportation Assistance Programs (LTAP), which are located in every state, are focused on disseminating information to all levels of government and to practitioners who may not be operating in the same organizations as the state DOTs. The success of LTAP has been proven without question, and this network provides a powerful opportunity for the best practices observed in this scan to be shared with a large segment of the industry.

AASHTO’s Technology Implementation Group (TIG) was established to assess and advance innovations in transportation technologies and practices. The best practices identified in this scan will be shared with the TIG as a means to further its distribution through the AASHTO organization and its affiliates.

The nature of the transportation industry requires a more aggressive means for distribution of the team’s findings. In order to facilitate this, the team has proposed preparing a CD with the information gathered during this scan for ease of distribution to a wide audience that can then adopt innovations as appropriate.

FHWA has an established peer-to-peer network that allows agencies to request technical assistance from peer agencies. The findings of the scan team can be used as a catalyst to set up a peer assistance list for this topic.

The team is committed to implementing the findings of this scan. The national dialogue on effectively moving traffic on existing facilities remains one of the most important issues today. This scan identified many important programs, strategies, and technologies that would be of benefit to the motoring public at large if they were implemented by other transportation agencies.

Appendix A:

Amplifying Questions

Overview of the Agency Organization and Process for Transportation Planning

1. Please provide a brief overview of how your agency is organized. Where is transportation planning in the organization? Where is the program/project management function located in the agency? Where in the agency is the responsibility for working with the state's MPOs, including the development of plans and Transportation Improvement Plans (TIPs)? Where is the responsibility for developing and managing the Scan Technology Implementation Plan (STIP)?

2. How many MPOs are in the state? How many are TMAs? How many and which specific MPOs are in nonattainment areas? How, specifically, does the DOT and other state agencies relate to the MPOs? Is DOT a voting member playing an identical role to other MPO members?

3. Briefly describe your state's public transportation programs. Is public transportation owned and operated by the DOT or by some other entity(ies)?

4. What are the major fund sources for the state's transportation program? What percentage of the program is funded with federal funds? Does state funding derive from your general fund or a dedicated transportation fund? What percentage of your program is funded as "pay as you go" and what percentage is funded through bonding of various types? Has your state utilized any innovative funding? If so, please prove a few examples. Do you utilize public/private partnerships to fund transportation? How are the nonhighway modes, such as rail, ports, and general aviation, managed and funded?

5. Who makes decisions regarding selection of transportation projects: your agency, the legislature, a transportation commission, or some other mechanism?

6. Where is responsibility for *revenue forecasting* located? Where is responsibility for developing and managing *fund allocations* for program development? What methodologies do you use to project future revenue growth at both the state and federal levels? Do you utilize the flexibility afforded in federal law and regulation to "flex" federal highway funds to public transportation?

7. Where is responsibility located for developing project *cost estimates* at the planning phase? Is one office in the agency responsible for overseeing cost estimation throughout the life of a project? How are project handoffs managed during the life of a project? How often do you require cost estimates to be formally updated? Does cost estimating responsibility shift to another part of the agency during each phase of a project? Specifically, how are change orders during the construction phase managed? Are reasonable contingencies required for most projects to guard against the cost impact of discovering changed conditions, scope changes, or unanticipated inflation? What, if any, is your guidance on including contingencies in the cost estimate at different phases of a project's development?

8. Have you utilized the authority to provide cost ranges for projects that are in the out years of your plans?

Transportation Program Development/Planning—TIP and STIP Development

1. Before we explore the detail, please provide an overall assessment of how your state and the MPOs are managing compliance with fiscal constraint and YOE federal requirements.

2. Describe the statewide and MPO planning process. How often is the statewide plan updated? How often are MPO plans updated?

3. Please describe your working relationship with the various MPOs in your state.

4. Please provide an overview of the program development process in your agency. Do you establish strategic goals/priorities? Describe your methodology for developing *revenue forecasts* for both *long-term plans and program development, including TIPs and the STIP*. Do MPOs participate in developing revenue estimates to be used in their plans and/or the TIP?

5. Do you have a regular cycle for performing program updates? How often do you develop new TIPs and a new STIP? What is the duration for approved TIPs and the STIP? What is the time cycle and process for TIP/STIP revisions between major updates?

6. How are other modes, such as rail, ports, and aviation, funded in your state?

7. Do state budget cycles impact your regular cycle for program updates? If so, how?

8. What is your fund-allocation methodology? Are allocations developed for specific goals/priorities/transportation operators? Could you provide examples of these goals/priorities? Are program decisions made centrally in the agency or in a decentralized manner through districts, regions, and/or MPOs?

9. Do you allocate federal funds based upon apportionment, obligation authority, or some other means? Which do you use in determining fiscal constraint? Are specific formulas used for each federal fund source? Are allocations tied to program strategic goals/priorities? Is the maintenance program included in program development or are these investments programmed and managed separately? What specific activities do you generally include in your maintenance program? Do you utilize federal funds for any of these activities, and, therefore, include them in your TIPs/STIP?

10. Do you have a formal cost *estimating methodology* applied uniformly across the state? Do you have a formal project management system responsible, in part, for ensuring that cost estimates are appropriately managed from project concept through construction completion?

11. Do you provide to recipients that are eligible to use federal transportation funds (e.g., DOT districts, local governments, MPOs, and transit operators) guidance on how they should comply with federal requirements on achieving *fiscal constraint* and expressing project costs in terms of *year of expenditure* (YOE)? Do you understand the rationale for requiring costs in YOE and do you agree with it? Do you provide

statewide guidance on *best cost estimating practices* to eligible project sponsors in the state? Do you provide a uniform methodology for calculating project inflation in future years of the program? If so, please describe this methodology. Do you provide flexibility to operators in calculating inflation for their individual programs?

12. Do you have air quality nonattainment and/or maintenance areas in your state? If so, have fiscal constraint issues impacted air quality conformity approvals? If so, how have you responded to this issue?
13. How do your plans, TIPs, and STIP respond to the federal requirement that there be "reasonable assurance that the federally supported transportation system is being adequately operated and maintained"?
14. Do individual MPOs develop their own requirements so that operators funded with federal funds have cost estimating methodologies that meet the federal requirements for YOE? Is MPO guidance to these operators adequate? Does the MPO have adequate resources to develop guidance and oversee implementation?
15. Does the agency have a policy or set of practices on how it responds if an MPO or other federal funds recipients develop a TIP or set of projects that exceed federal fiscal constraint requirements or does not express project costs in terms of YOE?
16. For your state's STIP, is there consistency between FHWA and FTA on definitions of fiscal constraint and application of YOE? Are you provided any latitude in conforming to federal requirements?
17. In summary, what are your most effective mechanisms for meeting federal requirements for fiscal constraint and expressing costs in terms of YOE? What are the most significant issues you face in trying to meet these requirements?
18. Has your use of any innovative contracting procedures (e.g., design/build) affected your efforts to comply with fiscal constraint?
19. How has the recent "stimulus" impacted efforts to comply with fiscal constraint, if at all?

Implementing and Managing Approved Long-Range Plans, TIPs, and STIPs

1. For approved TIPs and STIPs, does the agency have a formal policy for meeting federal fiscal constraint and YOE requirements? Through this policy or some other mechanism, do you identify threshold changes that require amendments to a TIP or STIP to maintain fiscal constraint? If so, would you identify these thresholds and how the amendment process is conducted? Do you distinguish between major and minor project cost amendments? If so, please describe.
2. Do individual MPOs determine their own processes for maintaining fiscal constraint as project costs change over time?
3. Could you describe the most effective examples of how an individual MPO maintains fiscal constraint during the life of its TIP? Do change orders during construction or project closeouts impact efforts to maintain fiscal constraint? How do you manage

project cost changes during construction within the STIP?

4. What are the major issues you face in attempting to maintain fiscal constraint?
5. Have the FHWA and the FTA approved the state's methodologies for maintaining fiscal constraint?
6. Have your current program and project management systems successfully controlled or limited the volatility in project costs during the life of the STIP? What are some of the most important elements of your systems that have led to this result? If volatility in costs continues to be a serious problem, what steps would you consider to reduce this volatility? How do you address a project bid that substantially exceeds the amount programmed for that specific project in your STIP? What is your approval process for such a bid and how is fiscal constraint maintained when such a bid is approved?
7. Are there changes the existing fiscal constraint and YOE federal planning requirements that you would recommend in the reauthorization of SAFTEA-LU? What specific changes, if any, would allow you to still achieve the objectives of these requirements? Why would these changes represent an improved approach to fiscal constraint?

MPO Responses to Fiscal Constraint and YOE Requirements (Questions for MPO Staff)

1. Describe the overall structure of your MPO, including the membership. Describe the state DOT's administrative and/or programmatic relationship to the MPO.
2. How frequently do you update your plan and your TIP? What is the duration for each? How frequently are project costs and schedules updated on your TIP?
3. What is the MPO's role, if any, in developing both *revenue and project cost estimates* that are used for your long-range plan and your TIP? Do you have a methodology for developing revenue forecasts for your plan and TIP? Is there an MPO-wide process for managing cost estimates that are included in you plan and TIP? What role, if any, do you play in determining federal allocations that are available to the MPO?
4. Do you or does the state establish priorities for programming available federal aid? Please describe the priority setting process used by your MPO.
5. Describe how you establish fiscal constraint as your TIP is developed. Do you provide eligible project sponsors guidance on *cost estimating*? If so, please describe. What guidance, if any, do you provide your individual operators on expressing project costs in terms of YOE, or do they determine their own methodology?
6. Once your TIP is approved and incorporated into the STIP, how do you ensure that fiscal constraint is maintained for the duration of the TIP? Describe your process for project amendments during the TIP's life. Are there clear thresholds for project cost and schedule changes that require an amendment? Do these vary by size of the specific project? Do you have a procedure for addressing minor changes to project costs and schedules that does not require a new demonstration of fiscal constraint?

7. What practices have you found particularly effective in establishing compliance with fiscal constraint and YOE requirements? What issues, if any, do you still face in complying with these requirements?
8. Are there changes in the current fiscal constraint and YOE planning requirements that you would recommend during reauthorization of SAFETEA-LU?

FHWA and/or FTA Division Perspective on Fiscal Constraint and YOE Compliance

1. Provide an overall assessment on how your state and the MPOs are meeting the compliance requirements for fiscal constraint and YOE.
2. Are you in agreement with your sister federal agency on what is required to ensure compliance at both the MPO and state levels?
3. What are some of the best practices that have assisted states and MPOs in meeting the requirements?
4. What issues related to compliance are you continuing to work with them on?
5. Are there specific steps that you are recommending that they consider in future compliance efforts?
6. Have there been any specific issues related to compliance in air quality nonattainment or maintenance areas?
7. Are there changes to the current regulations that you would recommend for consideration in order to better achieve the objectives of fiscal constraint and YOE?

Appendix B:

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Appendix C:

Scan Team Members Biographic Sketches

TED TREPANIER (AASHTO Co-Chair), formerly the state traffic engineer for the Washington State DOT and Director of the Traffic Operations Division, Trepanier has 25 years of experience in traffic and transportation engineering with WSDOT. In addition to his extensive background in traffic operations, he has experience in design, planning, project management, and toll operations. He serves on the AASHTO Standing Committee on Highway Traffic Safety, the Subcommittee on Systems Operation and Management, and the Subcommittee on Traffic Engineering. Trepanier earned his bachelor's degree in civil engineering from Washington State University and his master's degree in civil engineering from the University of Washington.

GREGORY JONES (FHWA Co-Chair) is a traffic management specialist for the FHWA. He has a dual appointment and works for both the headquarters' Office of Operations and the Resource Center out of the Atlanta, GA, office. In this role, Jones provides program management, policy development, technical assistance, and training support in the areas of managed lanes and regional transportation operations partnerships. He also provides technical assistance and training support for freeway management systems, active traffic management systems, and traffic management for major special events. Jones is the team leader for the joint FEMA/USDOT Hurricane Evacuation Liaison Team that coordinates multistate evacuations during major hurricanes. He is a member of many committees and task forces, including the TRB Subcommittee on Managed Lanes, and is a member of the NCHRP Panel for Traffic Flow on Managed Lanes. He is also the COTM for the FHWA summary report on the Efficient Use of Highway Capacity. Prior to his current position within the FHWA, Jones was a traffic system management specialist in the FHWA Resource Center, with responsibilities for traffic incident management, traveler information systems, emergency transportation operations, and development of ITS regional architectures. He also was the FHWA Regional ITS/Operations Specialist for the Southwest Region. Jones is a graduate of the University of Tennessee, where he earned a bachelor's degree in civil engineering.

JEANNE ACUTANZA is a traffic engineer and senior technologist with a national consulting firm. She has more than 25 years of experience in the field of traffic engineering and transportation planning, including alternatives evaluation, programming, planning and designing multimodal transportation solutions. Her transportation engineering skills are complemented by facilitation skills in context-sensitive solutions and familiarity with transportation policy. She has volunteered as a member of her community's Transportation Commission and currently co-chairs the Washington Traffic Simulation Roundtable, a technical subcommittee of the Institute of Transportation Engineers. Acutanza was on the organizing committee of the 2002 TRB HOV Mid-Year Conference and is a member of WTS. She has developed more than 10 conference papers focused largely on supporting infrastructure decision-making.

TONY S. ABBO is the assistant district engineer for Engineering Support and the acting district traffic engineer at the New Mexico DOT's (NMDOT's) District Three office in Albuquerque. He oversees all project programming, project development, traffic operations, traffic studies, and corridor studies and participates in the promotion of ITS technologies within NMDOT's District Three. He has 19 years with the NMDOT, holding positions in traffic design, traffic operations, and project development. During that time, Abbo lead several projects in which high-profile corridors and interchanges were reconstructed to address capacity deficiencies. He has played a major role in the development of the NMDOT's *Signing and Striping Manua*l and *Digital Message Signs Operations Manual*. Abbo is a graduate of the University of New Mexico, where he earned a bachelor's degree in civil engineering. He is a licensed professional engineer in New Mexico, a professional traffic operation engineer (PTOE), and a member of the Institute of Transportation Engineers.

MICHAEL P. PILLSBURY is the assistant director of Operations for the New Hampshire DOT (NHDOT). Pillsbury has more than 30 years of experience in the field of construction and engineering management. His current responsibilities include providing technical and administrative direction to the Bureaus of Highway Maintenance, Bridge Maintenance, Traffic, Mechanical Services, and Turnpikes. He is actively involved in the development of NHDOT's Transportation Management Center and the Traffic Control Committee for the state's NASCAR events. He is also the liaison with the state's Office of Emergency Management for evacuation planning. Pillsbury graduated from the University of New Hampshire with a bachelor's degree in civil engineering and is a licensed professional engineer in New Hampshire. He is the NHDOT's representative to AASHTO's Special Committee on Transportation Security and Emergency Management.

MARK DEMIDOVICH is the assistant state traffic engineer for the Georgia DOT (GDOT). He is responsible for the oversight of NaviGAtor, Georgia's statewide Intelligent Transportation System. He has been involved with the NaviGAtor system since its inception just prior to the 1996 Olympic Games in Atlanta. Demidovich has been with GDOT for nearly 20 years, all in the areas of traffic operations and ITS. Some recent projects under Demidovich's oversight have been the rollout of more than 140 ramp meters in metropolitan Atlanta, the expansion of NaviGAtor from 150 to 280 centerline miles, and the outsourcing of the GDOT TMC operation. He is on the development team to convert a section of Atlanta's lane system from HOV to HOT. Demidovich was recently elected vice-president of ITS Georgia and has served on its board. He is the GDOT representative in the TMC Pooled Fund study. Demidovich has a bachelor's degree in civil engineering from Clemson University and is a licensed professional engineer in Georgia.

LEE NEDERVELD is an operations engineer with the Michigan DOT (MDOT), working with the System Operations and Management (SOM) section in Lansing. He works primarily with the ITS unit and is responsible for overseeing and assisting with the management of multiple ITS contracts within the department. Nederveld is currently working with several agencies, consultants, and contractors on development of a statewide advanced transportation management system that will combine operation of all ITS devices statewide into one software solution. He is serving as program administrator for the ENTERPRISE Pooled Fund program while MDOT is the lead administrative state . He was previously the operations manager of the West Michigan Traffic Management Center in Grand Rapids. Nederveld is a graduate of Michigan State University, where he earned master's and bachelor's degrees in civil engineering.

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Appendix E:

Comparison Of Tools And Strategies For Tour Locations

The following tables provide comparative information for various strategies for maximizing flow on existing highways. The tables reflect 2009–2010 available data provided by each agency visited.

Jurisdiction	Miles of freeway	Loops	Dynamic message signs	Cameras
NJDOT		211	108	220
MnDOT		5500	110	450
Caltrans D4		1500	100	292
Caltrans D11	357,500	12,000[a]	35,107 CMS[b] 7953 RMS	430 106
Caltrans D7				
WSDOT				

[a] 1,986,268 traffic monitoring stations

[b] Content management system

Table E.1 ***Operations Center Comparison***

Jurisdiction	Year constructed	Agencies housed	Cost	Size
McConnell PSTOC, VDOT	2008	VDOT, State Patrol, 911 call center, Fairfax County	$120M (20% was VDOT)	
NJ/STMC	2009	NJDOT, NJTA, State Police		
MnDOT	2003	MnDOT. State Police, Public Information (radio)		53,000 ft^2
Caltrans D4		Caltrans, CHP		
Caltrans D11	1996	Caltrans, CHP	$17.5M (1994)	12,000 ft^2
	2007	CHP with 43 distinct function		

Table E.2 ***Operations center comparison***

Jurisdiction	Number of ramps metered	FWY/FWY	Algorithm	HOV bypass
McConnell PSTOC, VDOT	20	I-66 and I-395	ASSIST	
MnDOT	430	I-395, I-35	Max two minutes (service ramps) and four minutes (system ramps)	
Caltrans D11	288	Nine locations 125N–8W 67S–8W 15S–94W 15N–94W 805S/N–94W 8E–125S 43rd–805N		162 locations include HOV bypass lane
Caltrans D7	1200 with 953 (LA/Ventura)	I-210 at SR 134, SR 2, 118	SWARM	Metered
WSDOT	120	N/A		

Table E.3 ***Ramp metering comparison***

Jurisdiction	Traffic signals	Agencies coordinated with	Retiming schedule
McConnell PSTOC, VDOT		Fairfax County	2 years
Kassoff, MSHA	1400	Montgomery	3 years
NJDOT STMC			
MnDOT	670	All local agencies	3 to 4 years with 7-year statewide
Caltrans D4			
Caltrans D11	493 (2010)	All local agencies	5 Years
Caltrans D7	1300	Local agencies	Adaptive traffic control 3 to 4 years

Table E.4 ***Traffic signal coordination***

Jurisdiction	Year constructed or planned	Routes
MnDOT		I-35, SR 394
WSDOT		I-5, I-90, SR 520

Table E.5 ***Active traffic management/expressways***

Jurisdiction	Miles of highway	Service patrols (agency)	Incidents responded to annually	Clearance responsibility
Northern NJ STMC	GS/TPK NJDOT PANY NJ	160 tunnel bridge agents		
MnDOT		7 to 9 FIRST		
Caltrans D4		29 service/25 local (private)		
Caltrans D11	536			
Caltrans D7	1100	CHP, Caltrans, and metro operate Freeway Service Patrol	4600	Caltrans and CHP

Table E.6 ***Incident response***


BERKELEY 38 MIN
SF DWNTWN 87 MIN
OAK ARPT 58 MIN
CALL 511


REDUCE SPEED
SPEED LIMIT
EXIT 9 1 MILE
18 1
New Brunswick
East Brunswick